PCT

WORLD INTELLECTUAL PROPERTY ORGANIZATION
International Bureau

INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification 7 : H01M 12/06, 2/02

A1

(11) International Publication Number: WO 00/36689

(43) International Publication Date: 22 June 2000 (22.06.00)

(21) International Application Number: PCT/US99/28253

(22) International Filing Date: 30 November 1999 (30.11.99)

(30) Priority Data:

60/112,292	15 December 1998 (15.12.98)	US
09/293,458	15 April 1999 (15.04.99)	US

(71) Applicant (*for all designated States except US*): ELECTRIC FUEL LIMITED [IL/IL]; Western Industrial Park, P.O. Box 641, 99000 Bet Shemesh (IL).

(72) Inventors; and

(75) Inventors/Applicants (*for US only*): ABRAMSON, Mariano [IL/IL]; Carmon Street 16, Jerusalem (IL). DOPP, Robert, B. [US/US]; 1925 Fields Pond Glen, Marietta, GA 30068 (US). SHRIM, Yaron [IL/IL]; Mazel Shor Street 20/1, Jerusalem (IL).

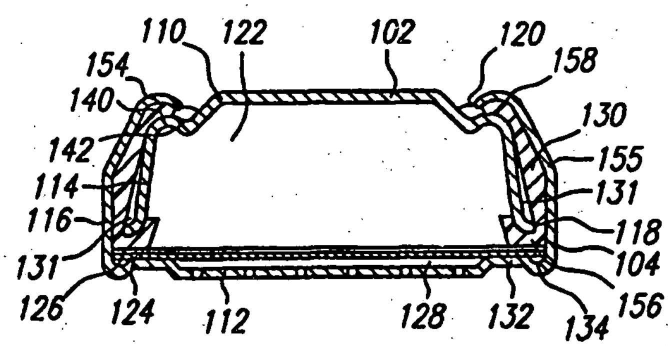
(74) Agent: CATAN, Mark, A.; Lyon & Lyon LLP, 633 West Fifth Street, Suite 4700, Los Angeles, CA 90071-2066 (US).

(81) Designated States: AE, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CR, CU, CZ, DE, DK, DM, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, SL, TJ, TM, TR, TT, TZ, UA, UG, US, UZ, VN, YU, ZA, ZW, ARIPO patent (GH, GM, KE, LS, MW, SD, SL, SZ, TZ, UG, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GW, ML, MR, NE, SN, TD, TG).

Published

With international search report.
Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.

(54) Title: STRUCTURE FOR A PRISM-SHAPED METAL-AIR BATTERY CELL WITH FEATURES TO PREVENT ELECTROLYTE LEAKAGE AND TO MAINTAIN CONNECTIVITY BETWEEN AN AIR CATHODE AND A CASING ELEMENT



(57) Abstract

A prism shaped battery cell has at least two casing elements. The casing elements are mutually engageable and are assembled by bending or crimping a portion of one casing element at least partially around a second casing element. The shape of the casing elements as well as the materials of the casing elements reduce the likelihood that the casing will corrugate during the crimping process. By reducing the size of the walls of a casing element at the corner portions, the negative effects of corrugation due to crimping are reduced. The casing elements also contain features that support a generally planar electrode in a position within the battery cell so that the edge of the electrode maintains contact with a casing element.

FOR THE PURPOSES OF INFORMATION ONLY

Codes used to identify States party to the PCT on the front pages of pamphlets publishing international applications under the PCT.

AL	Albania	ES	Spain	LS	Lesotho	SI	Slovenia
AM	Armenia	FI	Finland	LT	Lithuania	SK	Slovakia
AT	Austria	FR	France	LU	Luxembourg	SN	Senegal
AU	Australia	GA	Gabon	LV	Latvia	SZ	Swaziland
AZ	Azerbaijan	GB	United Kingdom	MC	Monaco	TD	Chad
BA	Bosnia and Herzegovina	GE	Georgia	MD	Republic of Moldova	TG	Togo
BB	Barbados	GH	Ghana	MG	Madagascar	TJ	Tajikistan
BE	Belgium	GN	Guinea	MK	The former Yugoslav Republic of Macedonia	TM	Turkmenistan
BF	Burkina Faso	GR	Greece			TR	Turkey
BG	Bulgaria	HU	Hungary	ML	Mali	TT	Trinidad and Tobago
BJ	Benin	IE	Ireland	MN	Mongolia	UA	Ukraine
BR	Brazil	IL	Israel	MR	Mauritania	UG	Uganda
BY	Belarus	IS	Iceland	MW	Malawi	US	United States of America
CA	Canada	IT	Italy	MX	Mexico	UZ	Uzbekistan
CF	Central African Republic	JP	Japan	NE	Niger	VN	Viet Nam
CG	Congo	KE	Kenya	NL	Netherlands	YU	Yugoslavia
CH	Switzerland	KG	Kyrgyzstan	NO	Norway	ZW	Zimbabwe
CI	Côte d'Ivoire	KP	Democratic People's Republic of Korea	NZ	New Zealand		
CM	Cameroon			PL	Poland		
CN	China	KR	Republic of Korea	PT	Portugal		
CU	Cuba	KZ	Kazakstan	RO	Romania		
CZ	Czech Republic	LC	Saint Lucia	RU	Russian Federation		
DE	Germany	LI	Liechtenstein	SD	Sudan		
DK	Denmark	LK	Sri Lanka	SE	Sweden		
EE	Estonia	LR	Liberia	SG	Singapore		

STRUCTURE FOR A PRISM-SHAPED METAL-AIR BATTERY CELL WITH FEATURES TO PREVENT ELECTROLYTE LEAKAGE AND TO MAINTAIN CONNECTIVITY BETWEEN AN AIR CATHODE AND A CASING ELEMENT

Cross Reference to Related Applications

Priority is claimed to the following United States Patent Applications: serial number 09/293,458, filed on April 15, 1999 and serial number 60/112,292 filed on December 15, 1998.

SPECIFICATION

Field of the Invention

The present invention relates to leak-proof structures for prism-shaped electrochemical cells, in particular, metal-air cells. More particularly, this invention relates to aspects of the structure of the cell casing that reduce corrugation at curved portions of the cells, reduce the likelihood that electrolyte will leak out of the cells, and that improve the electrical connectivity between an air electrode and a casing element.

Background of the Invention

The growth in use of small, electrically powered devices has increased the demand for electrochemical battery cells that are capable of providing more power while occupying a smaller volume. These devices demand sturdy leak-proof, and lightweight containers that can house the chemicals and other internal components of, for example, a battery cell and provide for their convenient electrical interconnection and connection to the device. The consumer's demand for these devices places considerable small size and weight limitations on battery designs, not just in terms of volume but also in terms of pure shape. To provide the maximum energy for a given space, it is necessary for a battery cell or an arrangement of closely packed battery cells to conform substantially to a specified given space, so as to minimize wasted space and maximize stored energy. Since many electronic devices are designed to house a battery that is substantially rectangular in shape, prism-shaped cells are particularly suited to powering these devices.

Further, to reduce the weight of the battery cells, it is preferable for the container to be made of a thin, light material. In many battery cells, the container makes up a large fraction of

the weight of the cell. The need to minimize the thickness of the material must be balanced against the need for strength since electrochemical cells can place severe demands on cell housing designs.

The present invention relates to prism-shaped battery cells having casings that are at least partly made of metal or a material that is deformable as metal. The benefits of using a metal casing include the use of the casing as integral electrodes as well as the many well-known cost, manufacturability, strength, and precision features that metal provides.

In certain types of electrochemical cells, external and internal force can generate tremendous loads that must be resisted or compensated. For example, in zinc-air battery cells, the oxidation of the zinc anode to generate current causes the anode to expand considerably. Volume increases of up to 60% have been reported. Hydrogen may be produced by the parasitic reaction of zinc with the cell's alkaline electrolyte. Hydrogen is even produced when the battery cell is dormant. If not permitted to vent out of the battery cell at a reasonable rate, the built-up hydrogen may further increase the internal pressure of the battery cell. Increased internal pressure can compromise the mechanical integrity of the cell's casing, causing it to leak electrolyte, short circuit, and, potentially, even explode.

To solve these problems, for example, a known metal casing design (e.g., button cells) has two major casing elements that are insulated from each other by a grommet or an alternative sealing element positioned between the casing elements. The grommet prevents the casing elements from contacting each other and also effectively seals electrolyte in one portion of the cell from other parts of the cell. However, if the casing becomes deformed, the dimensions of the gap occupied by the grommet may change, and electrolyte may work its way around the grommet and leak through that gap. Further, the raised internal pressure of the casing can force electrolyte out through the gap.

In certain battery cells – in particular, metal-air battery cells – the surfaces of the battery cells have small air access holes to permit the exchange of gases. In metal-air battery cells, ambient oxygen reacts with the metal anode to generate current. The holes are the means through which ambient oxygen can enter the battery cells. One of the risks of having holes in the cells is the possibility that electrolyte will leak out of the battery cell through the same holes. Further, the risk is exacerbated by the possibly raised internal pressure of the casing.

Casing deformation causes electrical shorts when the metal casing elements contact each other or when opposite-polarity electrode materials inside the cell come into contact. Casing deformation can also cause the battery cell to lose electrical contact with the electronic device. A change in the dimensions of the battery cell can cause the electrodes to separate from the electrical contacts of the electronic device.

To solve these problems, battery cell designers have traditionally made metal casings that are substantially cylindrical in shape. Such button-shaped battery cells are intrinsically strong and are commonly used to power watches, hearing aids, etc. Forces applied to the major surfaces of a button cell are resisted by the inherent strength of the cylindrical structure.

Referring to Fig. 1, a button cell 10 has an internal pressure that is greater than ambient pressure. The button cell 10 has two major casing elements 12, 14 that are engaged to form a button-shaped enclosure. A peripheral bend portion 16, which shapes the outer casing element 12 over the inner casing element, prevents the two casing elements 12, 14 from separating. An internal pressure, which is represented by a force F_1, pushes the two casing elements 12, 14 in a direction of separation from each other. This separation force F_1 is resisted by a force F_2, which is the force that the bend portion 16 exerts on the separating casing elements 12, 14. Since the casing elements 12, 14 are relatively cylindrical, the forces F_1, F_2 are resisted by the inherent hoop strength of the smaller-radius portion of the bend portion 16 of the outer casing element 12. The even distribution of forces also ensures a uniform seal between the casing elements 12, 14.

Because of its cylindrical shape, a button cell benefits from the hoop strength of the vertical wall. Referring to Fig. 2, a button cell 20 has two casing elements engaged to each other. The inner and outer casing elements each have a side wall 22, 24, respectively, with a grommet 26 positioned therebetween. When the button cell 20 is subjected to a high internal pressure F_3, the diameters of the side walls 22, 24 may change. (The diameter of the internal side wall 22 changes due to the force of the internal pressure, and the diameter of the external side wall 24 changes due to the force exerted by the internal side wall 22 via the grommet 26). Even if the diameters change, the grommet 26 adequately seals the casing elements together. The stress and strain of the side walls 22, 24 are relatively uniform around the circumference of the casing elements, with the side walls 22, 24 efficiently resisting the strain induced by the internal pressure.

Unlike the button cell of Fig. 2, the side walls of a prism-shaped cell do not experience the same uniform stress and strain. Referring to Fig. 3, a rectangular, prism-shaped cell 30 also has two casing elements with the inner casing element having four side walls 32 and the outer casing element having four side walls 34 and a grommet 36 positioned between the side walls 32, 34. When the prism-shaped cell 30 is subjected to a relatively higher internal pressure F_4, the side walls 32, 34 tend to distort because they lack the inherent strength that a cylindrical shape has to resist deformation. Due to the inherent characteristics of a prism-shaped cell 30, the side walls 32, 34 do not maintain their shape. The centers of long spanning side walls tend to deflect a greater distance from their original position causing significant deformation and leakage problems. The strain around the perimeter of the side walls 32, 34 of the prism-shaped cell 30 are considerably more variable than the strain around the circumference of the button cell of Fig. 2.

Because of these problems, non-button shaped battery cells have heretofore not been commercially produced, despite the obvious benefits in terms of packing density. That is, rectangular prism-shaped battery cells can fill a common rectilinear battery pack design with a significantly higher packing density than button cells, making the use of button cells unattractive. Solutions to the inherent weaknesses of prism-shaped cells must be addressed before prism-shaped battery cells can become a commercially feasible alternative.

In a prism-shaped cell, casing deformation can present serious problems. Unlike button-shaped battery cells, the forces due to increased internal pressure are not distributed uniformly around the perimeter of the cell of a prism-shaped cell, nor can the forces be adequately resisted by hoop strength. A prism-shaped cell normally has long spans running from corner to corner. The long spanning wall portions of such a prism-shaped cell are inherently weak and susceptible to deformation.

Referring to an example of the prior art illustrated in Fig. 4 and similarly pictured in United States Patent No. 5,662,717, a metal-air button cell 40 has two interfacing, inter-engaging casing elements 42, 52. The cathode and anode casing elements 42, 52 are shaped to each have a substantially cylindrical-shaped side wall 46, 56, a major wall structure or base 48, 58, a peripheral corner 50, 60 positioned between the wall 46, 56 and the base 48, 58, and a peripheral edge 44, 54 forming an opening of the casing element 42, 52, respectively. These casing elements 42, 52 are assembled so that the bases 48, 58 form two oppositely positioned

and oppositely charged surfaces of the battery cell 40. A grommet 62 positioned between the side walls 46, 56 electrically insulate and seal the casing elements 42, 52, and an approximately 45 degree bend 43 of the cathode casing element 42 prevents the casing elements 42, 52 from disengaging.

The prior art example also illustrates the peripheral edge 54 of the anode casing element 40 as being sharp, which often results from a shearing operation in the manufacturing process. This sharp edge 54 can dig into and damage the grommet 62, causing electrolyte leakage and possibly a short circuit. Further, this sharp edge 54 can also bring about an undesired chemical reaction. For example, in a zinc-air battery cell, the casing element can be made of a nickel-stainless steel-copper triclad with a coating or film separating these metals from the zinc anode. All three of the tri-clad metals, if exposed to the zinc anode, can chemically react, resulting in the production of hydrogen or the introduction of contaminate ions into the electrolyte. The coating or film inhibits this reaction. However, the shearing operation of the manufacturing process can expose the underlying nickel, increasing the rate of the reaction.

The prior art example of Fig. 4 also illustrates the side walls 46, 56 of the casing elements 42, 52 as being relatively perpendicular to the major surfaces 48, 58. In other words, the side walls 46, 56 are parallel. One problem with this configuration relates to the assembly of the battery cell 40. Since the internal components are placed on the bottom (near the base 48) of the cathode casing element 42, the components must work its way down the entire height of the side wall 46. Dimensional tolerances in the components of the casing element 15 may cause the components to get stuck or become distorted as they move to their ultimate location.

The prior art example of Fig. 4 also illustrates the placement of the grommet 56 between the relatively smooth surfaces of the casing elements 42, 52. As is well documented elsewhere, many different types of electrolyte, e.g. KOH, can flow easily across metal surfaces. Scratches on the surfaces of the casing elements 42, 52 can act as channels through which electrolyte can migrate and eventually leak out of the battery cell 40. Electrolyte leakage can cause the battery cell 40 to short circuit or even explode.

United States patent 5,537,733 describes a method for manufacturing a rectangular nickel-metal hydride secondary cell, and U.S. patent 5,556,722 describes a prism-shaped

casing for a lithium ion-type cell. These patents point out features but do not allude to prism-shaped cells.

U.S. patents 4,374,909 and 4,656,104 relate to casings for metal-air button-type battery cells. None of the patents teaches a solution for achieving a strong prism-shaped metal casing capable of use in such applications as metal-air batteries.

In fact, none of the above mentioned patents teaches or discusses how certain shape features of the container can be used to increase its strength and reduce or prevent unwanted deformation or bulging.

Summary of the Invention

The present invention provides a metal casing with features that reduce the likelihood that portions of the casings with corrugate when the battery cells are assembled. By shaping the curved portions of the side walls of a casing element of the cell, the likelihood that a portion of the casing will corrugate when the battery cells are assembled are reduced. One example of a casing element shape is a casing element having shorter side walls at the curved portions than at the straight portions. By reducing the quantity of material near the corner portions, a casing element is less likely to corrugate when bent or crimped during the assembly process. Corrugation of the casing element may result in electrolyte leaking out of the battery cell.

A similar result is also accomplished by using annealed metal or a softer metal near the corner portions. Altering the crimping process may also reduce corrugation. By crimping the casing elements to different magnitudes at different portions of the casing element, corrugation can be reduced. For example, if the casing element is bent to a lesser degree at the corner portions, the corner portions are less likely to bunch up and corrugate.

The present invention also provides structural features in the casing elements for improving the electrical connectivity between an air cathode and a casing element. In a metal-air battery cell, the air cathode is generally a flat, planar structure coated with an insulating material with an outer, exposed edge for electrically connecting the air cathode to a casing element. The air cathode electrically charges the casing element, which is then used by the electrical application as the cathode of the battery cell.

The present invention is a metal-air battery cell with a casing element that supports the air cathode and positions the air cathode so that the edge of the air cathode contact and press against the casing element at an angle preferably close to 90 degrees so that an electrical connection is achieved. Since the air cathode is typically covered with an insulating coating with its edge exposed, the edge is the avenue by which electrical charge is conducted to other parts of the battery cell and ultimately to the electrical application. A poor contact angle between the air cathode and the casing element, such as an angle closer to 0 degrees, may cause the air cathode to bend and lose electrical connectivity. For example, the air cathode may bend to form the shape of the inside surface of the casing element with the edge of the air cathode bent away from the casing element. To achieve the desired contact angle, the air cathode is offset from the general planar major surface of the casing element and away from round corners formed on the inner surface of casing element. These round corners may cause the air cathode to bend away from the casing element.

The invention relates to a metal prism-shaped casing with features that make the casing strong, unlikely to deform, and leak electrolyte leakage. The present invention also provides features that make the battery cell more reliable, inexpensive and mass-manufactureable. Ridges on the interior and exterior of the flat surfaces of the battery cell are formed to add strength to the casing. These ridges eliminate or reduce the tendency of the battery cells to bulge due to an increase in the internal pressure of the cell. The side walls of the casing elements flare outwards from the flat surface to prevent the walls from collapsing inwardly and to make the battery cell easy to assemble. The side walls are also shaped to provide for a better seal between the casing elements, thus preventing electrolyte from leaking. Tar or another liquid type sealant coats a grommet positioned between the casing elements to prevent electrolyte leakage. The grommet also serves to separate and insulate the two casing elements. Further, a diaper ring placed between the casing elements absorbs electrolyte that may have worked its way past the grommet.

The casing element has a well or catch basin to catch adhesive or electrolyte that has managed to work its way past the separator. The basin also provides an inexpensive means for ensuring that the air cathode remains electrically connected to the cathode casing element. The basin eliminates the need to manufacture a casing element with sharp interior corners. The shape of the basin further strengthens the casing elements.

While the invention will now be described in connection with certain preferred embodiments and examples and in reference to the appended figures, the described embodiments are not intended to limit the invention to these particular embodiments. On the contrary, it is intended to cover all alternatives, modifications, and equivalents as may be included within the scope of the invention as defined by the appended claims. Thus, the following description and examples of the preferred embodiments of the invention are only intended to illustrate the practice of the present invention. The particular embodiments are shown by way of example and for purposes of illustrative discussion of the preferred embodiments of the present invention. While the embodiments are described in relation to a metal-air battery cell, the invention is not limited solely to this type of battery cell. Parts of the invention can also be applied to alkaline and other primary battery cells. Prism-shaped metal-air battery cells are illustrated in the description of the invention because the metal-air battery cells are particularly suitable for describing many of the features of the invention. While the embodiments are described in relation to a rectangular shaped battery cell, the invention is not limited to battery cells having rectangular casings. Instead, the invention covers all prism-shaped battery cells, including but not limited to hexagonal, octagonal, and other cells having casings with relatively straight side walls.

The particular embodiments are presented in the cause of providing what is believed to be the most useful and readily understood description of the principles and conceptual aspects of the invention. In this regard, no attempt is made to show structural details of the invention in more detail than is necessary for a fundamental understanding of the invention. The description, taken with the drawings, makes it apparent to those skilled in the art how the several forms of the invention may be embodied in practice.

Brief Description of the Drawings

Fig. 1 shows a cross-section representation of a button-shaped battery cell with vectors representing some of the forces that are present when the internal pressure is greater than ambient.

Fig. 2 shows a different cross-section representation of a button-shaped battery cell.

Fig. 3 shows a cross-section representation of a prism shaped battery cell with an internal pressure that is greater than ambient.

Fig. 4 shows a cross-section representation of a prior art example of a button-shaped metal-air battery cell.

Fig. 5 shows an enlarged, partial cross-section representation of the embodiment of Fig. 4.

Fig. 6 shows a cross-section representation of the embodiment of Fig. 4 with collapsing side walls.

Fig. 7 shows a partial cross-section representation of one example of the prior art.

Fig. 8A shows a cross-section representation of a prism-shaped battery cell according to one embodiment of the invention.

Fig. 8B shows a different cross-section representation of the embodiment of Fig. 8A.

Fig 9 shows a cross-section representation of an uncrimped cathode casing element of one embodiment of the invention

Fig. 10 shows a perspective view of the uncrimped cathode casing element of Fig. 9

Fig. 11 shows a perspective view of a cut-out portion of a cathode casing element under a bending moment.

Fig. 12A shows a perspective view of an uncrimped cathode casing element according to an alternative embodiment of the invention. The casing element has notches at the rounded corners.

Fig. 12B shows a perspective view of another uncrimped cathode casing element according to an alternative embodiment of the invention.

Fig. 12C shows a cross-section representation of an assembled battery cell according to an alternative embodiment of the invention.

Figs. 12D(1) and 12D(2) shows two enlarged partial cross-section representations of a single embodiment according to the invention.

Fig 13 shows a cross-section representation of an anode casing element of the embodiment of Fig. 8.

Figs. 14 - 18 show enlarged partial cross-sectional representations of edges of an anode casing element according to alternative embodiments of the invention.

Figs. 19 – 21 show cross-section representations of ridges or ripples on a base of a casing element according to alternative embodiments of the invention.

Fig. 22 shows a perspective view of an anode casing element having ridges attached to its interior surface, according to an alternative embodiment of the invention.

Fig. 22A shows a perspective view of a Teflon ® ring for incorporation into an embodiment of the invention

Fig. 23 shows an enlarged partial cross-section representation of a peripheral rim of the cathode casing element crimped around a peripheral rim of the anode casing element with vectors representing interacting forces, thereof.

Fig. 24 shows a force vector representation of the peripheral rim of Fig. 23.

Figs. 25A – 25B show partial cross-section representations of a single embodiment. The figures demonstrate the need for an engagement bend of an outer casing element to conform to shape of the inner casing element.

Fig. 26 shows a cross-section representation of an alternative embodiment of the invention. The embodiment has a double bend to reduce the effects of "spring back."

Figs. 26A – 26B show enlarged partial cross-section representations of the embodiment of Fig. 26, according to an alternative embodiment of the invention.

Fig. 27 shows a partial cross-section representation of another alternative embodiment of the invention.

Figs. 28 – 29 show two partial cross-section representations of two alternative embodiments of the invention. The embodiments are designed to increase stresses in certain areas to limit electrolyte leakage.

Figs. 30A and 30B show two enlarged cross-section representations of the embodiment of Fig. 8.

Fig. 30C shows a cross-section representation of an air cathode according to one embodiment of the invention.

Fig. 31 shows a cross-section representation of an air cathode according to an alternative embodiment of the invention.

Fig. 32 shows a cross-section representation an not yet crimped cathode casing element with internal components. The area dimensions of the internal components are sized to be slightly larger than the area dimensions that they are designed to occupy. This embodiment is an alternative embodiment of the invention.

Fig. 33 shows a partial cross-section representation of the embodiment of Fig. 32 after assembly.

Figs. 33A – 33C are cross-section representations of three alternative embodiments of the invention.

Fig. 34 shows a cross-section representation of an alternative embodiment of the invention. The embodiment utilizes a snap-fitting strap to ensure that the casing elements remain engaged.

Figs. 35 – 38 show partial and full cross-section representations of an alternative embodiment of the invention. The embodiment utilizes two cathodes to generate current.

Fig. 39 shows a cross-section representation of an embodiment similar to the embodiment of Figs. 35 – 38 according to the invention.

Detailed Description of the Illustrated Embodiments

Figs. 8A and 8B show an assembled prism-shaped metal-air battery cell 100 having two major casing elements, an anode casing element 102 and a cathode casing element 104. The casing elements 102, 104 are substantially rectangular tray-shaped casing elements with a respective major wall structure or base 110, 112, continuous side walls 114, 116 meeting at corners 106, 108, a bend portion between the base 110, 112 and the side walls 114, 116, and a peripheral edge 118, 120. In this embodiment, the bend portion of the anode casing element 102 is a peripheral trough 142 and a peripheral rim 140, and the bend portion of the cathode casing element 104 is a peripheral ledge 132 and a peripheral basin 134.

Within the enclosure formed by the casing elements 102, 104 are the internal components of the cell 100, including a metal anode 122, an air cathode 124, a separator 126 and a diffuser 128. An insulated grommet 130 separates the side walls 114, 116 of the casing elements 102, 104 and prevents the casing elements 102, 104 from contacting each other. The grommet 130 also protects the air cathode 124 from the anode casing element 102 and seals the casing elements 102, 104 together. An anode current collector (not shown) electrically connects the metal anode 122 to the anode casing element 102, and a cathode current collector (not shown) electrically connects the air cathode 124 to the cathode casing element 104.

The casing elements 102, 104 are mutually engaged to each other and remain engaged by bending the side walls 116 of the cathode casing element 104 partially around the anode casing element 102, preferably by a crimping process. The assembly process creates a compressive stress in the grommet 130 and the casing elements 102, 104, which seals the battery cell 100. The stress is primarily derived from forces in the axial direction due to the shape of the casing elements 102, 104 during and after the assembly process is complete. This stress persists, at least partially, after the assembly process so that a seal is effectuated. Further, the air cathode 124 may contain a layer or two of uncompressed Teflon® which further seals the air cathode 124 to the cathode casing element 104. A more thorough discussion of the assembly process and the stresses are discussed hereinafter.

The cathode casing element 104 of the battery cell 100 contains features that increase its strength and improve the reliability and manufacturability of the battery cell 100. Referring now to Figs. 9 and 10 showing an uncrimped cathode casing element 104 before assembly, the peripheral ledge 132 and the peripheral basin 134 increase the strength and rigidity of the casing element 104 and also provide reliability benefits described hereinafter. The ledge 132 and the basin 134 increase the strength and rigidity of the cathode casing element 104 by translating a portion of a load to the much stronger, rounded corners 108. This load can be due to external forces or resistance to internal pressure. Note that basin 134 helps to prevent collapse illustrated in Fig. 6, for example.

For example, referring now to Fig. 11 showing a perspective view of a cut out portion of the casing element 104, a bending moment - as would be generated by a force F applied to the center of the span and resisted by fixed support points S - is resisted by the curves of the ledge 132 and the basin 134. The ledge 132 and the basin 134 translates a concentrated force applied in one area of the casing element 104 by spreading the force more evenly around the ledge 132 and the basin 134 areas, including areas near the corners 108. The casing element 104 subjected to a load along one of its long spanning walls, is able to resist deformation by transferring part of the load to the rounded corners 108.

Referring back to Figs. 9 and 10, the side walls 116 of the "uncrimped" cathode casing element 104 widens from the peripheral basin 134 to the edge 120. This outward flare may assist with the manufacture of the metal-air battery 100 by making it easier for the manufacturer to place the internal components into the cathode casing element 104. The flare

helps guide the components during assembly and permits full insertion of the parts without distortion of those parts. This feature is particularly advantageous when inserting the an air cathode 124 since the air cathode can be very delicate. Since the area dimensions of the opening of the cathode casing element 104 are larger than the area dimensions of the bottom of the cathode casing element 104, the internal components of the battery cell 100 should be able to easily slide into the cathode casing element 104.

When the battery cell 100 is fully assembled, the crimping or bending process may, although not necessarily, eliminate the flare, making the side walls 116 substantially perpendicular to the major surface 112 and the peripheral ledge 132.

As shown in Fig. 8A, assembling the battery cell 100 requires the manufacturer to bend or crimp the cathode casing element 104 at least partly around the anode casing element 102. However, bending the edge 120 around the corners 106 of the anode casing element 102, may cause portions of the cathode casing element 104 to corrugate which may result in a poor electrolyte seal. To reduce corrugation and the negative effects of corrugation, the cathode casing element 104 can be made of a very soft or annealed metal at the portions that are prone to corrugation. In some instances a small degree of corrugation may be acceptable.

Referring now to Fig. 12A, in an alternative embodiment, notches 136 are cut near the corners 108 of the cathode casing element 104 to reduce the amount of excess material when the edge 120 is bent. Excess material can corrugate and compromise the seal. In addition, if the excess material is compressed to its elastic phase, it can elongate and form an electrical bridge to the anode casing element 102, causing the battery cell 100 to short circuit. The notches 136 solve this problem by reducing the amount of excess material.

Referring now to Fig. 12B, in another alternative embodiment, reduction of excess material to prevent corrugation and short circuiting can be accomplished by forcing the basin 134 downwardly at portions near the corners 108. The figure shows the effect very exaggeratedly. Creating depressions, such as by a "forcing" process, draws excess material from the walls 116 into the basin 134 and, in essence, shortens the height of the walls at the corners 108.

In an alternative solution to the problem of corrugation, the cathode casing element 104 can be bent to different degrees along its edge 120. The casing element 104 can be bent further along the side portions of the casing element and less along the corner portions.

Referring now to Fig. 12C, corner portions 139 of the cathode casing element 104 are not bent around the anode casing element 102 to the same degree as portions along the sides of the battery cell 100, making the edge 120 rise slightly around the corner portions 139. This solution reduces corrugation by reducing the amount of shortening deformation near the corner portions 139 while still adequately sealing the casing elements 102, 104 together. The effect of less crimping in the corners can be seen in the cross-sections shown in Figs. 12d(1) and 12d(2). Fig 12d(1) shows a partial cross-section representation of the side portions of the cell and Fig. 12d(2) shows a partial cross-section representation of the corner portions of the same cell.

Referring back to Fig. 10, air access holes 138 on metal-air battery cells may be a source of electrolyte leakage. The base 112 of the cathode casing element 104 has a plurality of air access holes 138 that are sized and populated to ensure that the air cathode 124 has sufficient access to oxygen. Oxygen is needed by the battery cell 100 to generate current. Increasing the size of the air access holes may increase the supply of oxygen to the air cathode 124. Unfortunately, larger air access holes 138 may also increase the likelihood that electrolyte will leak out through the air access holes 138 and may also increase the rate that the metal anode 122 desiccates. Larger air access holes 138 may permit electrolyte to freely pass through while smaller air access holes 138 may restrict the flow through the holes 138. The surface tension of a liquid or gel like electrolyte may prevent the electrolyte from passing through smaller sized air access holes 138.

Air access holes 138 that have a diameter of 0.4 – 0.5 mm can be repeatedly punched in a metal casing having a thickness of 0.1 – 0.4 mm without undue maintenance of the punches. Smaller sized holes 138 were found to be more difficult to punch.

A preferred approach in designing a cathode casing element 104 to limit excessive desiccation and electrolyte leakage while providing sufficient air access is through experimentation. Using an agreed upon and constant dimensions of the air holes 138, determine the electrical energy generated by an agreed upon and constant dimensions of a metal-air battery 10 when different cathode casing elements 104, having different but uniform distances between each air hole 138, are used. As the density of the air holes 138 increases, the number of air holes 138 that can fit on the base 112 increases and the total current generated by the battery cell 100 should also increase. At some point, however, the total

current will decrease or remain constant. This point occurs when the area supplied by each air hole 138 significantly overlaps the area supplied by an adjacent air hole 138. Further increasing the density of the air holes 138 may unnecessarily increase the rate by which the battery cell 100 desiccates without contributing significantly to the oxygen supply to the air cathode 124.

Decreasing the distance between each air hole 138 increases the number of the air holes 138 and also increases the likelihood of electrolyte leakage. Fewer or smaller sized air holes 138 reduce the likelihood that electrolyte will leak out through the air holes 138.

The anode casing element 102 also contains features that increase its strength and improve the reliability of the battery cell 100. Referring now to Fig 13, the peripheral rim 140 and the peripheral trough 142 increase the strength and rigidity of the casing element 102, and do so in substantially the same way as the ledge 132 and the well 134 of the cathode casing element 104. The rim 140 and the trough 142 spread out a concentrated force to the round corners 106 of the anode casing element 102.

Referring to the prior art example of Fig. 5, the design of the side wall 56 of the anode casing 52 are prone to collapse due to an external force. The relatively parallel side walls almost invite a collapse. Referring now to Fig. 6 showing a collapsing battery cell, the side walls are bent so that the peripheral edge 54 is deflected inwardly. This collapse can arise from the external forces applied during the crimping process or from excessive bulging of the base 58 of the anode casing element 52. In a button cell, the strength of its cylindrical shape can resist this type of deformation. In a prism-shaped cell, the shape is less able to completely resist deformation.

Referring back to Fig. 13, because of the high axial loads due to crimping, the cell walls 114 must endure extreme forces. The flare of the anode casing element 102 helps to insure that both casing walls 114, 116 cooperate to support the cell 100. The outward flare engages the base 112 of the cathode casing element 104 to ensure that the type of buckling illustrated in Fig. 6 does not occur.

The outward flare can also improve the electrical connection between the cathode collector (not shown) and the cathode casing element 104 and also improve the effectiveness of the separator 126. The axial force from the assembling process causes the peripheral rim 144 of the anode casing element 102 to press against the separator 126 and the air cathode

124, via the grommet 130. The axial force also cause the sloping side walls 114 and the ends of the walls to deflect outwardly, which pushes the edges of the air cathode 124 and the separator 126 against the cathode casing element 104 and improves the electrical connection between the cathode current collector and the casing element 104.

When the edges of the cathode 124 are pressed against the casing element 104, the cathode current collector (not shown) forms a better electrical connection with the casing element 104.

Referring to Fig. 13, the shape of the peripheral rim 144 provides increased reliability by protecting the grommet 130. The rim 144 directs the sharp edges of the peripheral edge 118 away from the portion of the grommet 130 that is prone to damage when an axial force pushes the rim 144 against the grommet 130 These axial forces exist when the battery cell 100 is assembled and even exist after assembly.

The cutting and punching process that is performed to form the casing element 102 may form a sharp edge 118, and that edge 118 may damage the grommet 130 by digging into and shearing the grommet 130. To protect the grommet 130, the rim 144 is shaped so that the edge 118 does not dig into the grommet 130, but rather the smooth surfaces of the rim 144 press against the grommet 130, thereby distributing the axial forces over a larger area of contact.

Other examples of alternative shaped rims 144 are illustrated in Figs. 14-18. In Fig. 14, a rim 145 has a bend of approximately 180 degrees, which distances the edge 118 even further from the portion of the grommet most susceptible to damage. In Fig. 15 a rim 146 has a bend in the opposite direction, or inwardly. In this embodiment, the cathode casing element 104 does not need to be shaped to accommodate the space occupied by an outward protrusion of the rim 146. The grommet 130 can be thinner and the anode casing element 102 can be sized to hold a larger quantity of the metal anode 122. In Fig. 16, a rim 147 is shaped to have two bends. The rim 147 provides the benefits of a thinner grommet 130 and a larger capacity anode casing element 102 as in the previous embodiment. In addition, the rim 147, through its multiple bends, provides increased strength and rigidity, making it less susceptible to collapsing. Further, the rim 147 also protects against an undesired chemical reaction between the casing element 102 and the metal anode 122. As discussed previously, a casing element made of a nickel-steel-copper triclad can react with a zinc anode to produce hydrogen or to

introduce contaminant ions into the electrolyte. The nickel is normally coated to prevent the undesired chemical reaction. However, the nickel may become exposed at the edges 118 during the formation of the casing element 102. In this embodiment, the rim 147 distances the edge 118 away from the metal anode 122. Referring now to Figs. 17 and 18, in an alternative embodiment, the edges are smooth and rounded so that they do not contain sharp edges.

Referring now to Figs. 13 and 19, the base 110 of the anode casing element 102 has ridges 146 that run from the peripheral trough 142 on one side of the casing element 102 to the peripheral trough 142 on the opposite side. Although not illustrated, the base 112 of the cathode casing element 104 may also contain ridges, as well. These ridges 146 increase the rigidity of the base 110 and make the casing element 102 less susceptible to deformation under increased internal pressure.

The ridges 146 of the anode casing element 102 provide increased strength by transferring external forces on the base 110 to the rim 140 and the trough 142. These ridges 146 may be formed at the same time the cathode casing element 104 is crimped over the anode casing element 102, via an appropriately designed crimping tool. Cold forming ridges 146 on a thin, relatively flat metal surface, such as the major surface 110, creates ridges 146 on both sides of the metal surface and further increases the strength of the base 110.

Other examples of ridges are illustrated in Figs. 20, 21, and 22. Figs. 20 and 21 show two alternative arrangements with ridges 148, 150. Fig. 22 shows an anode casing element 102 with ridges 152 attached to its inner surface. The ridges 152 are relatively thin so as to limit the space it occupies, thereby leaving more room for the metal anode. These ridges 152 also increase the strength of the side walls.

Referring again to the prior art example as illustrated in Fig. 4, due to the shape of the cell 40, the bend 43 is inherently strong. Deforming a cylindrical shaped element so that the edge is bent inwardly creates a very strong hoop that is resistant to extension. The bend 43 can then resist deformation and disengagement of the casing elements 42, 52 through its hoop strength. Also, as explained before, the battery cell 40 remains sealed due to the even distribution of forces around the circumference of the battery cell 40.

Unfortunately, not all of the inherent advantages of button cells can be reproduced in prism-shaped cells. For example, a similarly designed bend in a prism-shaped cell does not

provide the cell with the same strength and rigidity qualities of a button cell. Bending the casing element over long straight sides can easily be straightened towards its original position.

Further, a bend of a mere 45 degrees, as in the embodiment of Fig. 4, is not particularly strong considering the lack of compression deformation described above, the dimensions of many types of battery cells, and the "spring back" effect of metal when it is bent. For example, if the bend 43 of the cathode casing element 42 springs back and the side wall 46 begins to flare outwardly, the two casing elements 42, 52 may becoming disengaged. Simply increasing the degree of bend does not solve all the problems since it can cause the edges 44 of the cathode casing element 42 to corrugate at the corners and become the source of electrolyte leakage. Further, increasing the degree of bend may cause the cathode casing element 42 to contact the anode casing element 52 resulting in an short circuit.

United States Patent number 5,432,027 titled "Button-Type Battery Having Bendable Construction, and Angled Button-Type Battery" also does not solve the problems inherent in prism-shaped battery cells. This patent relates to a thin button cell capable of being deflected without destroying the operation of the button cell and without rupturing the peripheral seal. Referring to Fig. 7 showing a partial cross-section of the crimp of the above mentioned patent, the casing elements are held together by a "C-shaped fluid type crimp seal." While this seal may prove effective for very thin battery cells having no, or very short, side walls, it is not particularly effective for thicker prism-shaped battery cells. Very thin button cells do not experience the effect of a thicker, bulging battery cell, which may cause the inner casing element to slide out of the C-shaped crimp, or alternatively, cause the crimp to open. Further, the C-shaped crimp occupies an excessive amount of space in the lateral direction, thereby reducing the main benefit of a prism-shaped cell.

Referring back to Fig. 8A, to assemble the battery cell 100, the cathode casing element 104 is bent or crimped over the peripheral rim 140 of the anode casing element 102, forming a bend 154. Due to the elasticity of metal, the cathode casing element 104 tends to spring back when bent. Although the crimping or bending process causes the material to be deformed well beyond its elastic limit, there may be some elastic rebound. To avoid the elastic rebound and its attendant deleterious effect on the integrity of the seal, the bend 154 should be subjected t a high degree of strain. In the embodiment of Fig. 8A, the side wall 116 also contains a bend 155 to accommodate the outward protrusion of the rim 144.

The bend 154 prevents the casing elements 102, 104 from uncoupling. By bending or crimping the casing element 104 far enough so that a portion of the bend 154 extends towards the base 112, the bend 154 prevents the side walls of the cathode casing element 104 from uncoupling and the casing elements 102, 104 from disengaging. The protrusion of the rim 140 of the anode casing element 102 and the thickness of the grommet 130 prevent the bend 154 from deflecting laterally. Essentially, the bend 154 "hooks" over the rim 140 to prevent the side wall 104 from being pushed out.

The bending process can be accomplished by further crimping the peripheral basin 134 by a pinching process so that the outward flare of the side walls 116 is reduced or eliminated. Then, while pressing the anode casing element 102 against the cathode casing element 104, the cathode casing element 104 is crimped around the peripheral rim 140 by a similar pinching process.

To reduce the negative effects due to elastic rebound when the cathode casing element 104 is crimped, the anode casing element 102 should be firmly pressed against the cathode casing element 104 and the grommet 130 should be compressed at positions 156 and 158. Compressing the grommet 130 while crimping the cathode casing element 104 improves the seal of the battery cell 100. The resiliency of the grommet 130 can fill any gaps between the casing elements 102, 104 and the grommet 130 that are created if the cathode casing element 104 springs back. Even after the cathode casing element 104 springs back, the grommet 130 is still at least partially compressed at positions 156 and 158 so that a tight seal is maintained at those points. The resiliency of the grommet 130 forms the seal.

Preferably, the grommet 130 is shaped so that an air filled void 131 is created between the seal near the cathode 156 and the seal near the edge of the cathode portion of the cell casing 158. Without a void 131, any electrolyte that has managed to work its way past the seal at position 156 may be assisted, through a capillary effect, with its migration to the seal at position 158. The void 131 reduces or eliminates this capillary effect by significantly enlarging the channel through which electrolyte can flow.

Although not illustrated here, the peripheral basin 134 can be even further crimped so that the side walls 116 of the cathode casing element 104 bow inwardly. Further bending may ensure that the casing element 104 does not peel back from the peripheral rim 140 when internal pressure builds up and the battery cell 100 begins to bulge. Overcrimping may also

resist the tendency of the battery cell 100 to bulge at the side walls 114, 116 by compensating for increased pressure buildup. Further, such crimping may increase the interacting forces between the side walls 114, 116, thereby improving the effectiveness of the grommet 130 to seal the battery cell 100. Greater forces between the grommet 130 and the side walls 114, 116 may create a better seal.

The resiliency of the grommet 130 also ensures that a seal is maintained between the air cathode 124 and the peripheral ledge 132. The air cathode 124 may contain a generally planar layer of uncompressed Teflon® on the side that faces the base 112. When the battery cell 100 is assembled, the layer of uncompressed Teflon® is pressed against the ledge 132 and forms a seal, which prevents electrolyte from escaping through the air access holes 138. Uncompressed Teflon® is particularly suitable because of its gas permeability properties. Unfortunately, Teflon® is not very resilient. The portion of the Teflon® layer that contacts the ledge 132 remains at least partially compressed if the axial forces disappear. Therefore, to ensure that the seal is maintained, the grommet 130 should continuously press the air cathode 124 against the ledge 132.

The generally planar layer of uncompressed Teflon® is not a necessity and may be replaced with a flat, ring-shaped piece of Teflon®. Referring now to Fig. 22A, a Teflon® ring 190 is placed on, and shaped to cover, the flat portions of the ledge 132. The Teflon® ring 190 can also be attached to the air cathode 124, such that the Teflon® ring 190 is positioned between the air cathode 124 and the ledge 132.

In an alternative embodiment, the air cathode 124 can have a generally planar layer of uncompressed Teflon® and a Teflon® ring 190 attached to the planar layer. Two layers of Teflon® may further improve the seal between the air cathode 124 and the ledge 132. Also, the Teflon® ring 190 eliminates one layer of Teflon® between the air cathode 124 and the diffuser 128. Unnecessary layers of Teflon® can act as barriers between the air cathode 124 and the air access holes 138 and restrict the battery cell's 100 access to oxygen.

Unlike a button cell, which can resist deformation and disengagement of its casing elements through its hoop strength, the prism-shaped battery cell 100 of the present invention resists disengagement through substantially axial, interacting forces between the casing element 102, 104.

Referring now to Figs. 23 and 24, the cross-section of the curvature of the bend 154 substantially conforms to the shape of the rim 140 so that the lateral or non-axial components of the interacting forces that portions of the casing element 104 exert near the bend 154 and the rim 140 substantially cancel each other out. The remaining axial components of the forces press the anode casing element 102 against the cathode casing element 104. For example, the bend 154 exerts forces on the peripheral rim 140 represented by F_{10} and F_{11}. The lateral components of the forces F_{10X} and F_{11X} are substantially equal and opposite. The summation of the axial components of the forces F_{10Y}, F_{11Y} oppose the summation of the axial forces F_{12} that the anode casing element 102 exerts on the cathode casing element 104.

If the lateral components of the forces do not substantially cancel or if the bend 154 does not substantially conform to the rim 140, the battery cell 100 may deform and electrolyte may leak. For example, Figs. 25A and 25B illustrate the same battery cell under different internal pressure. The battery cell – which has a cathode casing element shaped to have a bend 172 and an edge 176 and an anode casing element shaped to have a rim 174 – may experience bulging when subjected to a high internal pressure. As the casing elements begin to separate due to increased internal pressure, the side walls of the cathode casing element may flare outwardly as the rim 174 of the anode casing element works its way towards the edge 176 of the cathode casing element. This outward flare may cause the battery cell to bulge and possibly leak electrolyte.

Referring now to Figs. 26, 26A, and 26B in an alternative embodiment, the casing elements 102, 104 remain engaged to each other through a severe bend feature, which in the example includes a first bend 168 of approximately 180 degrees and a second bend 170 of approximately 90 degrees. The advantage of this double bend feature is that the negative effects of spring back can be significantly reduced or eliminated. Unlike the bend 154 of the embodiment of Fig. 8A, a slight elastic rebound of either of the two bends 168, 170 will not significantly lessen the force that the cathode casing element 104 exerts on the peripheral rim 140 of the anode casing element via the grommet 130. In the embodiment of Fig. 8A, the grommet 130 is compressed at the same time that the bend 154 is formed. Any spring back of the bend 154 must be absorbed by the resiliency of the grommet 130 or electrolyte may leak. In the present embodiment, a minor spring back of the bends 168, 170 has a much less detrimental effect on the seal of the battery cell because the clamping distance – which is

measured from base to the contact point near the bend – does not significantly change. The likelihood of electrolyte leaking through a gap between the casing element is significantly reduced.

The reason this embodiment has the above benefit is that a marginal displacement due to elastic return has virtually no vertical displacement of the engagement surface. So an elastic return of the first bend 168 of a small angle φ has very little effect on the distance between a static vertical position line 102A and an engagement surface 170A. That is, the first bend 168 can rebound from position 168B to 168C with no substantial consequence on the structure of the cell.

To form the two bend feature, the second bend 170 should be formed before the first bend 168. The trough 142 of the anode casing element 102 should also be of a shape to leave room for the cathode casing element 104 during the formation of the crimp 168. Although not illustrated here, the portion of the casing element 104 above the second bend 170 can be shortened or altogether eliminated.

Referring now to Fig. 27, in an alternative embodiment, the cathode casing element 104 is bent to approximately 90 degrees. While this embodiment may lack some of the benefits of the bends of the embodiments of Figs. 8A and 26, this embodiment is particularly suitable for battery cells 100 that do not experience a high degree of internal pressure or external forces. The embodiment is much easier and less costly to manufacture and still provides resistance to forces which cause the casing elements to disengage. The casing elements 102, 104 prevent disengagement through a bend 185 of approximately 90 degrees and also through an adhesive attaching the grommet 130 to the casing elements 102, 104.

Referring back to Fig. 8A, the grommet 130 fills the gap between the casing elements 102, 104 so that the battery cell 100 is sealed and electrolyte does not leak. The grommet 130 is coated with a liquid or semi-liquid sealant to further improve the seal by filling the gaps between the grommet 130 and the side walls 114, 116 and by blocking the small channels in the casing elements 102, 104 caused by scratches on the surface of the side walls 114, 116. Tar has been found to be a particularly suitable substance. It is preferable that the substance be an electrically insulating substance so that a short circuit does not occur.

Referring now to Figs. 28 and 29 showing alternative embodiments, the shape of the casing elements 102, 104 create areas where the interacting forces between the casing

elements 102, 104 are more concentrated, thereby improving the sealing qualities of the grommet 130. In Fig. 28, the radius of the crimp 154 is greater than the radius of the rim 140 which concentrates the axial forces at approximately location 160. In Fig. 29, minor peripheral ridges or protrusions 162 create the same effect. Although not illustrated here, a seal can also be improved through the addition of minor peripheral ridges or protrusions of the surface of the grommet 130.

If electrolyte manages to work its way past the grommet 130, a diaper ring 162 can absorb the escaping electrolyte before it completely exits the battery cell 100. The diaper ring 162 is preferably located between the peripheral trough 142 of the anode casing element 102 and the crimp 154 or the edge 120 of the cathode casing element 104.

Referring back to the prior art example as illustrated in Fig. 5 which shows a partial and enlarged cross-section view of the prior art example of Fig. 4, an air cathode 64 is positioned near the base 48 of the cathode casing element 42 so that the air cathode 64 has access to oxygen via air holes (not shown) punched in the base 48. A cathode current collector (not shown) is embedded in the air cathode 64 and provides a means through which electric charge can flow. An edge 66 of the collector is exposed and contacts the cathode casing element 42, thereby electrically connecting the air cathode 64 to the cathode casing element 42.

The prior art example illustrates the corner 50 of the cathode casing element 42 as being rounded. A battery cell with interior rounded corner is less reliable. When the air cathode 64 is placed at the bottom of the cathode casing element 42, the rounded corner 50 may force the air cathode 64 with the embedded cathode current collector (not shown) to bend and conform to the shape of the rounded corner 50. Since the edge 66 of the current collector is the means through which the air cathode 64 electrically connects to the cathode casing element 42, a bend may cause the battery cell 40 to electrically disconnect. It is preferred that the edge 66 directly contact, or even better, dig into the cathode casing element 42.

The patent application titled "Metal-Air Cathode Can Having Reduced Corner Radius and Electrochemical Cells Made Therewith" and numbered 5,662,717 teaches of using a cathode casing element with a relatively sharp interior corner. Although the claimed benefit of a sharp corner relates to an improvement of the structure, an added benefit is increased reliability. The edges of a cathode current collector can dig into and contact the sharp corner.

However, a sharp interior corner also has its drawbacks. Sharp interior corners are difficult and expensive to manufacture. A relatively sharp die is usually required to form sharp interior corners, and sharp dies tend to dull very quickly. Constant sharpening and replacing is required.

Referring now to Figs. 30A and 30B which show partial cross-sections of the embodiment of Fig. 8A, the cathode casing element 104 has features which improve reliability and lower costs. The edges of the air cathode 124 and the separator 126 press against the side walls 116 of the cathode casing element 104, thereby ensuring electrical connectivity is maintained between the casing element 104 and a cathode current collector 125 embedded in the air cathode 124. It is preferred that the side walls 116 be substantially perpendicular to the air cathode 124 and the cathode current collector 125. Since only the edges of the current collector 125 are exposed, a less than perpendicular contact may result in the air cathode 104 being electrically disconnected from the casing element 104.

The shape and the size of the basin 134 and the ledge 132 ensure a substantially perpendicular contact. Unlike the prior art, which was discussed above and illustrated in Fig. 5, the present embodiment eliminates the likelihood that the air cathode 124 will bend and conform to the shape of round interior corners. Further, the embodiment eliminates the need for sharp corners, which can be expensive due to the repeated replacement and sharpening of dies used to make the sharp corners.

Another feature of the invention relates to the size and shape of the air cathode 124 and the separator 126. The area dimensions of the air cathode 124 and the separator 126 can be slightly larger than the area dimension that the components are intended to occupy. The slightly larger size ensures that that edges of the components press against the side walls 116, thereby ensuring a tight seal by the separator 126 and electrical connectivity with the current collector 125.

However, if the components are too large, the components may ripple when the battery cell 100 is assembled. One solution is to size the air cathode 124 so that only one of the two area dimensions is larger than the occupied dimensions. Fig. 30C exaggeratedly illustrates the size differences between a surface area representation 175 of the air cathode 124 before assembly and a surface area representation 177 of the area that the air cathode 124 is intended to occupy or "occupied representation". A length L_{175} of the pre-assembly representation 175

is longer and a width W_{175} is shorter than a length L_{177} and width W_{177} of the occupied representation 177, respectively. These size differences ensure that at least two edges of the current collector 125 contact the cathode casing element 104 and also reduce the likelihood that the air cathode 124 will ripple. If both the length L_{175} and width W_{175} of the pre-assembly representation 175 are larger than the respective dimensions of the occupied representation 177, the air cathode 124 may ripple, especially at its corners 179.

If the length L_{177} of the occupied dimension 177 is longer than its width W_{177}, it is preferred that the length L_{175} of the pre-assembly representation be longer than the length L_{177} of the occupied representation 177. The opposite holds true for the reverse scenario. In other words, it is preferred (though not necessary) for the air cathode 124 to have an area dimension that is longer than the corresponding area dimension of the occupied representation for that particular area dimension that is the longer of the two area dimensions. This configuration has been found to produce a better electrical connection with less rippling effects.

Fig. 31 exaggeratedly illustrates an alternative embodiment where corner sections 191 of a surface area representation 193 of the pre-assembled current collector 127 and the air cathode 124 extend out from a surface area representation 195 of the "occupied representation". These corners sections of the current collector 127 are a means by which the current collector 127 contacts the casing element 104.

Referring back to Fig. 30A and 30B, another feature of the basin 134 is that it can be used to catch electrolyte or adhesive that had managed to work its way around the separator 126. Although not shown here, a peripheral diaper ring, similar to the diaper ring 162 described above, can be placed in the recess of the basin 134 and absorb the electrolyte or adhesive before it can work its way out through the air access holes 138 of the cathode casing element 104.

Referring now to Figs. 32 and 33 showing an alternative embodiment, one of the area dimensions of the air cathode 124 and the separator 126 are larger that the corresponding area dimension of the occupied representation. Referring to Fig. 32, which shows the air cathode 124, the separator 126, and the cathode casing element 104 prior to the insertion of the anode casing element 102, the centers of the components 124, 126 bow away from the base 112 to form a gentle curve facing concave d wn.

After insertion of the anode casing element 102, as illustrated in Fig. 33, the components 124, 126 become flattened and bent near their edges. The resiliency of the components 124, 126 ensure that the separator 126 adequately seals and that the cathode current collector 125 electrically connects to the casing element 104.

Fig. 33A illustrates an embodiment similar to the embodiment of Figs. 8A, 30A and 30B. Instead of the single ledge 132 of Fig. 8A, the air cathode 124 is supported by multiple protrusions 310 formed on the base 112 of the cathode casing element 104. The protrusions 310 support the air cathode 124 so that the air cathode 124 remains substantially perpendicular to the side walls 116 of the casing element 104. Preferably, the protrusions 312 are uniformly distributed over the base 112.

Referring now to Fig. 33B, in an alternative embodiment, the protrusions 310 of the embodiment of Fig. 33A are replaced with a generally planar support structure 312. The support structure 312 is gas permeable so that a gas exchange between the air cathode 312 and an outside of the battery cell 100 is maintained. The support structure 312 supports the air cathode 312 in the desired perpendicular configuration with respect to the side walls 116 of the cathode casing element 104. In the alternative, the support structure 312 can also be shaped to form openings to enhance gas exchange.

Referring now to the embodiment of Fig. 33C, which is similar to the embodiment of Figs. 8A, 30A and 30B, the single ledge 132 and the basin 134 of Fig. 8A are eliminated from the cathode casing element 104. Instead, a ring-shaped support structure 314 supports the air cathode 124. The air cathode 314 is electrically connected to the ring structure 314. The ring structure 314 is a conductor and is electrically connected to the cathode casing element 104. The ring structure 314 support the air cathode 124 so that the air cathode 124 maintains a good contact with the air cathode 124. Preferably, the ring structure 314 is perpendicular to the air cathode 124 at the point where the electrical connectivity is maintained.

The use of the separate ring structure 314, instead of a casing element shaped to support an air cathode 124, may provide benefits in electrical connectivity and assembly. An air cathode 124 can be placed in the ring structure 314 and then placed in the cathode casing element 104. In this way, an assembler can more easily observe the contact between the air cathode 124 and the ring structure 314 before placement in the casing element 104. The ring structure 314 can also provide strength and rigidity when placing the air cathode 124 in the

casing element 104. Without the ring structure 314, the air cathode 124 may contact the side walls 116 of the casing element 104 during assembly, which may cause the air cathode 124 to bend.

Referring now to Fig. 34, in an alternative embodiment, a strap 166 resists any deformation and bulging of the battery cell 100. The strap 166 is snap fitted onto the battery cell 100. It is preferred that the strap 166 be made of an insulated and resilient material so that the strap does not cause the battery cell 100 to short circuit. Although not illustrated here, the casing elements can contain a recess shaped to fit the strap 166 so that the strap 166 is at least partially embedded in the cathode and/or anode casing elements 102, 104. The recess can ensure that the strap 166 remains in place and may also make the battery cell easier to connect to the electronic device. Also, depending on the configuration of the battery cell 100, the strap 166 may eliminate the need for crimping the cathode casing element 104.

Referring now to Figs. 35 - 38, in an alternative embodiment, an asymmetrical metal-air battery cell 200 has two cathodes 201 positioned on opposite sides of a metal anode 202. Above the two cathodes are two diffusers 203 and two metal cathode casing elements 204 having air holes 205. At least partly embedded in the metal anode 202 is an anode current collector 206, which is connected to an electrical lead 207. Within the pair of air cathodes 201 are a pair of cathode current collectors (not shown), which electrically connect the pair of air cathodes 31 to the respective cathode casing elements 204.

A grommet 208 firmly surrounds a portion of the electrical lead 207, thereby preventing the electrolyte from leaving the battery cell 200 via the hole through which the lead 207 passes. The grommet 208 also presses the air cathodes 201 into their respective cathode casing elements 204. Although not illustrated here, the electrical lead 207 can also be molded into the grommet 208 or the grommet 208 can be fitted and caulked to make a seal. The grommet 208 should be made of a resilient material so that the compressive forces of the grommet 208 can seal the two cathode casing elements 204 together. An example of suitable material for a grommet 208 is polysulfone.

A pair of semi-rigid straps 209 hold the contents of the battery cell 200 in place via snap-fits located at positions 210. The rigid straps 209 press the two cathode casing elements 204 together, which press against the two air cathodes 201 and compress the grommet 208.

Although not illustrated here, the cathode casing elements 204 can be glued directly to the grommet 208, instead.

The use of two air cathodes 201 and one anode 202 increases the power of the battery cell 200. Although both cathodes 201 have approximately the same nominal voltage with respect to ground, the increased air access through two cathode casing elements 204, instead of one, and the increased surface area of two cathodes 201, instead of one, results in a battery cell 200 that can generate more current.

Referring now to Fig. 39, in an alternative embodiment, two straps 211, when snap fitted onto the cathode casing element, substantially surround the perimeter of the battery cell.

It will be evident to those skilled in the art that the invention is not limited to the details of the foregoing illustrative embodiments, and that the present invention may be embodied in other specific forms without departing from the spirit or essential attributes thereof. The present embodiments are therefore to be considered in all respects as illustrative and not restrictive, the scope of the invention being indicated by the appended claims rather than by the foregoing description, and all changes which come within the meaning and range of equivalency of the claims are therefore intended to be embraced therein.

Claims

We claim:

1. A kit for making a leak proof casing for an electrochemical cell comprising:

first and second tray-shaped casing elements, each having a generally planar major wall with dependant side walls, said side walls meeting said major wall at a proximal bend that circumscribes said major wall;

said side walls being continuous to define a single continuous peripheral edge;

said side walls having relatively straight portions and curved corner portions where said straight portions meet;

said first casing element being shaped so as to be insertable into said second casing element such that it may form a prism-shaped enclosure cooperatively with said second casing element;

each of said casing elements having respective shapes such that when a distal portion, proximal of said peripheral edge, of said second casing element side walls is curved over said proximal bend of said first casing element to form a curved portion that may engage said first casing element, stresses tending to corrugate said peripheral edge are reduced to a level such that substantially no corrugation would occur.

2. A kit as in claim 1, wherein:

said second casing element is made at least partly of a metal; and

a material of said second casing element is more annealed at a portion closer to said curved corner portion of said second casing element than further from said curved corner portion.

3. A kit as in claim 1, wherein:

said second casing element is made at least partly of metal; and

a material of said second casing element is softer at a portion closer to said curved corner portion of said second casing element than further from said curved corner portion.

4. A kit as in claim 1, wherein said respective shapes include a shape of said second casing element such that a distance between said edge and said proximal bend of said second casing element is shorter at said corners portions than elsewhere.

5. A casing as in claim 4, wherein said respective shape includes a shortening of said side walls at said corner portions.

6. A casing as in claim 4, wherein said respective shape includes a shape of said second casing element is such as to have at least one recess in an immediate vicinity of a said second casing element proximal bend and of a said corner portion, and a shape of said second casing element peripheral edge follows a shape of said at least one recess.

7. A casing as in claim 1, wherein:

said second casing element has a recess in an immediate vicinity of said second casing element proximal bend and said second casing element; and

said peripheral edge follows a shape defined by said recess such that said peripheral edge is closer to said major wall in a vicinity of said corner portions than elsewhere.

8. A leak proof casing for an electrochemical cell comprising:

first and second casing elements mutually engageable to form a prismatic enclosure;

said first casing element having a planar major wall and a single continuous depending side wall perpendicular to said major wall and joined to said major wall at a proximal bend, whereby said side wall and said major wall enclose a prism-shaped volume;

said side wall having straight portions and curved corner portions where said straight portions meet;

said side wall of said first casing element having a distal edge portion wrapped over said second casing element to mutually engage said first and second casing elements; and

at least one of said first and second portions being shaped such that said distal edge portion is bent through a smaller range of curvature near said corners than further from said corners, whereby a compressive strain of said distal edge portion is minimized.

9. A casing as in claim 8, wherein a portion of a curve formed by said distal portion of said second casing element has a radius of curvature that is greater than a radius of curvature of a portion of the proximal bend of the first casing element that is closest to said distal portion of said second casing element.

10. A leak-proof casing for an electrochemical cell comprising:

first and second tray-shaped casing elements, each casing element having a generally planar major wall with generally perpendicular dependent side walls, said side walls meeting said major wall at a proximal bend that circumscribes said major wall;

said casing elements being mutually engageable to form a prism-shaped enclosure;

said proximal bend of at least one of said casing element defining a recess and a ledge;

said ledge being shaped to support a generally planar electrode so that said electrode is substantially parallel to said major wall; and

said recess and said ledge being shaped such that when the electrode is supported by said ledge, the electrode may remain substantially perpendicular to said side walls without bending.

11. A leak proof casing as in claim 10 wherein said recess and ledge are shaped such that a portion of said recess of said at least one of said casing element is disposed on a same side of a planar projection of said ledge as said major wall.

12. A leak proof casing as in claim 10 wherein said ledge is shaped such that when the electrode is supported by said ledge, said generally planar electrode is offset from said generally planar major wall.

13. A leak proof casing as in claim 10 wherein said at least one of said casing elements includes two separate casing elements.

14. A leak-proof casing for an electrochemical cell comprising:

first and second tray-shaped casing elements, each casing element having a generally planar major wall with generally perpendicular dependent side walls, said side walls meeting said major wall at a proximal bend that circumscribes said major wall;

said casing elements being mutually engageable to form a prism-shaped enclosure;

said major wall of at least one of said casing element having protrusions to support a generally planar electrode so that said electrode is substantially parallel to said major wall; and

said major wall being shaped such that when the electrode is supported by said protrusions, the electrode may remain substantially perpendicular to said side walls without bending.

15. A tray shaped casing element for an electrochemical cell comprising:

a tray shaped casing element having a generally planar major wall with generally perpendicular dependent side walls, said side walls meeting said major wall at a proximal bend that circumscribes said major wall;

said tray shaped casing element being mutual engageable with a second casing element to form a prism shaped enclosure;

said proximal bend defining a recess and a ledge, said recess being proximal to said side walls and said ledge being proximal to said major wall;

said ledge being shaped to support a generally planar electrode so that said electrode is substantially parallel to said major wall;

said recess and said ledge being shaped such that when the electrode is supported by said ledge, the electrode may be pressed against the inner surface of the casing element proximal to said proximal bend when said casing element is mutually engaged with said second casing element.

16. A casing element as in claim 14 wherein said recess and said ledge is shaped such that when the electrode is supported by said ledge, an edge of the electrode is within the confines of said recess when said casing element is mutually engaged with said second casing element.

17. A tray shaped casing element for an electrochemical cell comprising:

a tray shaped casing element having a generally planar major wall with generally perpendicular dependent side walls, said side walls meeting said major wall at a proximal bend that circumscribes said major wall;

said tray shaped casing element being mutual engageable with a second casing element to form a prism shaped enclosure;

said tray shaped casing element shaped to support a generally planar air cathode a distance from said major wall, said air cathode supported in a position to contact said dependent side walls perpendicular thereto.

18. A tray shaped casing element as in claim 17 wherein said major wall has a raised portion, said raised portion supporting said air cathode.

19. A tray shaped casing element as in claim 18 wherein said raised portion defines a ledge around a perimeter of said major wall.

20. A tray shaped casing element as in claim 18 wherein said raised portion is a plurality of protrusions formed on said major wall and distributed over said major wall.

21. A tray shaped casing element as in claim 17 wherein said support includes a support structure disposed between said major wall and said air cathode such that a direct contact of said major wall and said air cathode is prevented.

22. A tray shaped casing element as in claim 17 wherein said casing element include two separate casing elements, a major casing element being a tray shaped structure having a generally planar wall and dependent side walls and a minor element being shaped to support said generally planar air cathode a distance from said major wall.

23. A method of assembling a metal-air battery cell comprising the steps of:

placing a generally planar air electrode in a rigid support structure that supports an outside edge of said air electrode such that a contact of said air electrode to said support structure is capable of transferring an electrical charge; and

placing a combination of said air electrode and said support structure in a tray-shaped casing element such that a contact of said combination to said casing element is capable of transferring an electrical charge.

24. A method of assembling a metal-air battery cell as in claim 23 wherein said combination of said air electrode and said support structure is more rigid than said air electrode.

25. A method of assembling a metal-air battery cell as in claim 23 wherein in said second mentioned placing step said contact is between said support structure and said casing element.

26. A method of assembling a metal-air battery cell as in claim 23 wherein:

said tray-shaped casing element has a generally planar major wall with generally perpendicular dependent side walls, said side walls meeting said major wall at a proximal bend that circumscribes said major wall; and

said casing element and said support structure are shaped such that said electrode is maintained a distance from said major wall after said second mentioned placing step.

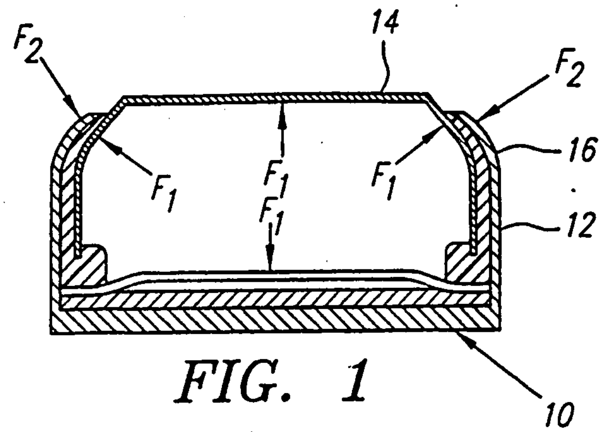


FIG. 1

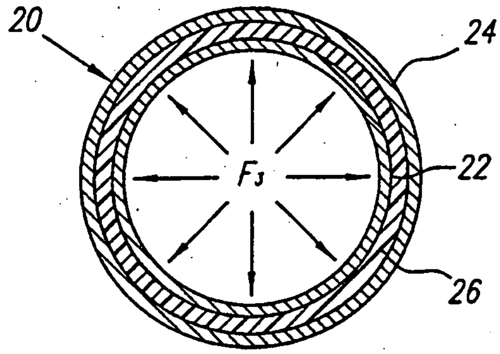


FIG. 2

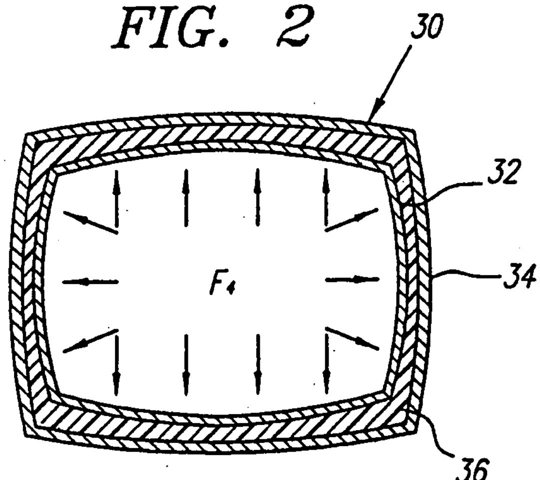


FIG. 3

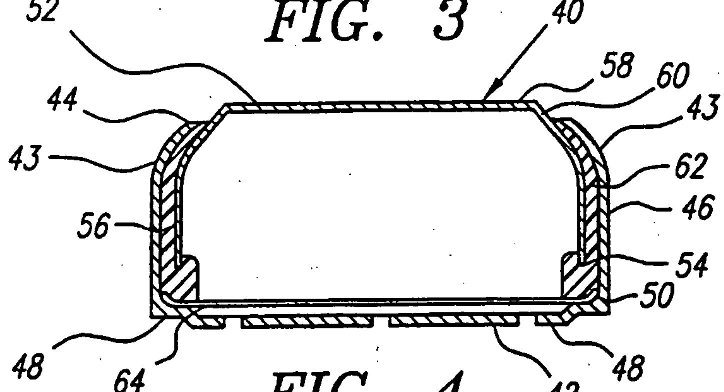


FIG. 4

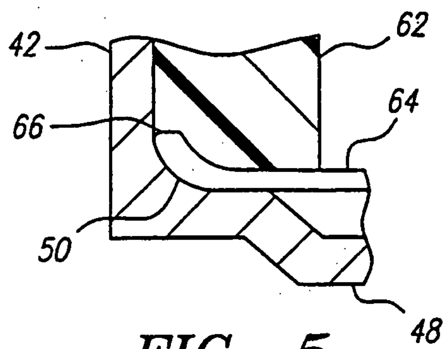


FIG. 5

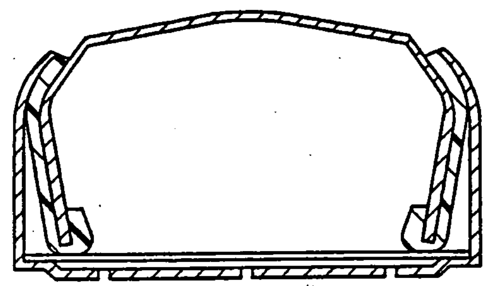


FIG. 6

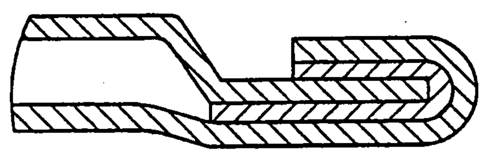


FIG. 7

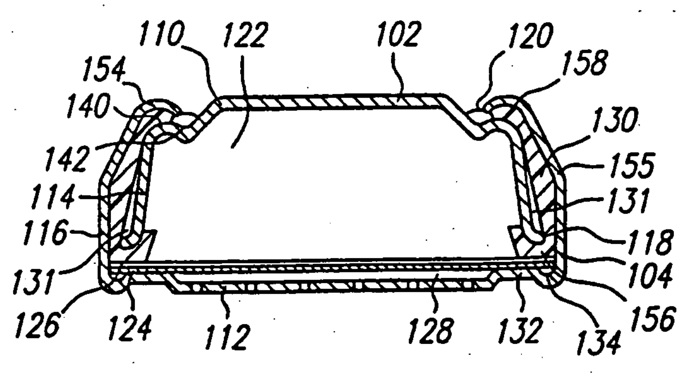


FIG. 8A

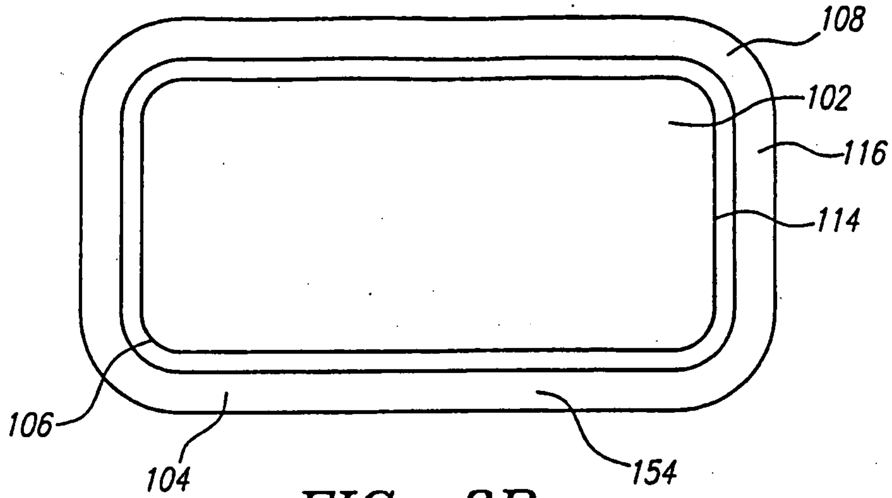


FIG. 8B

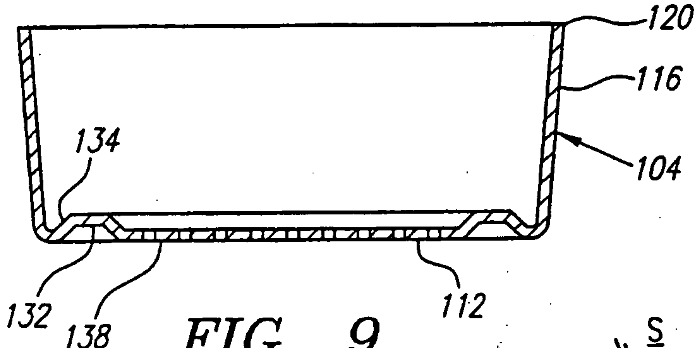
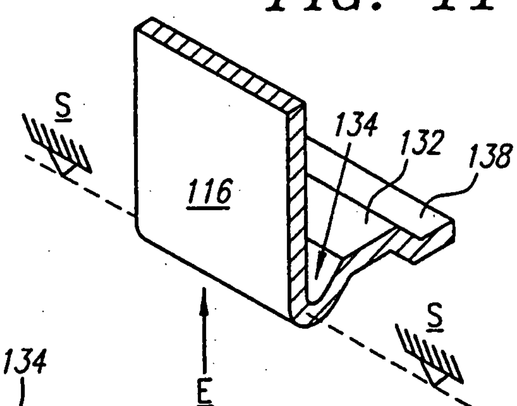


FIG. 9

FIG. 11



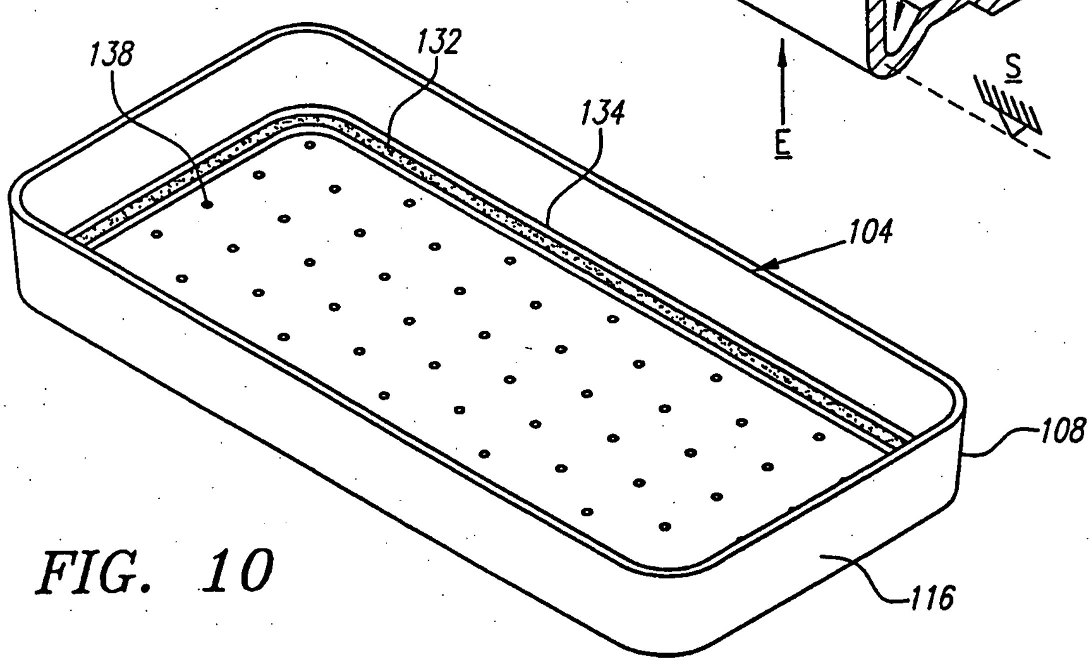


FIG. 10

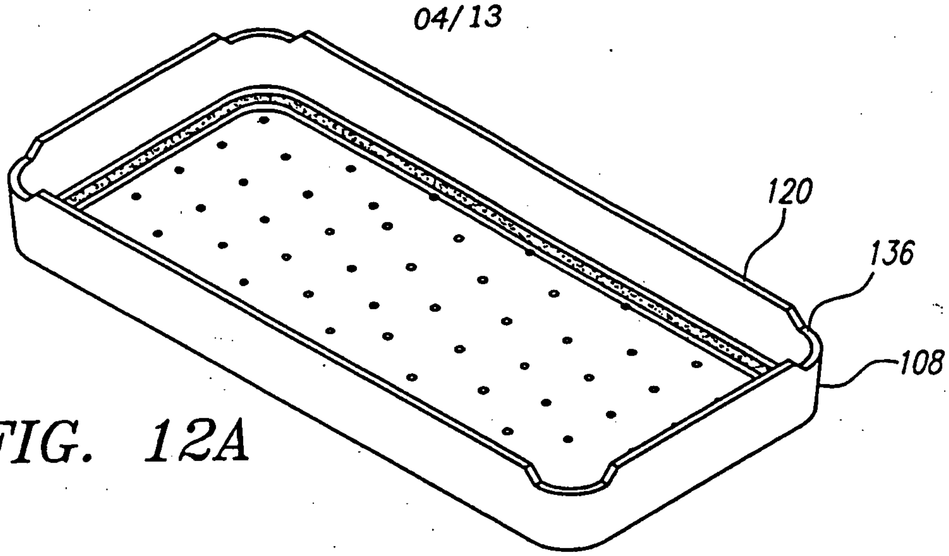


FIG. 12A

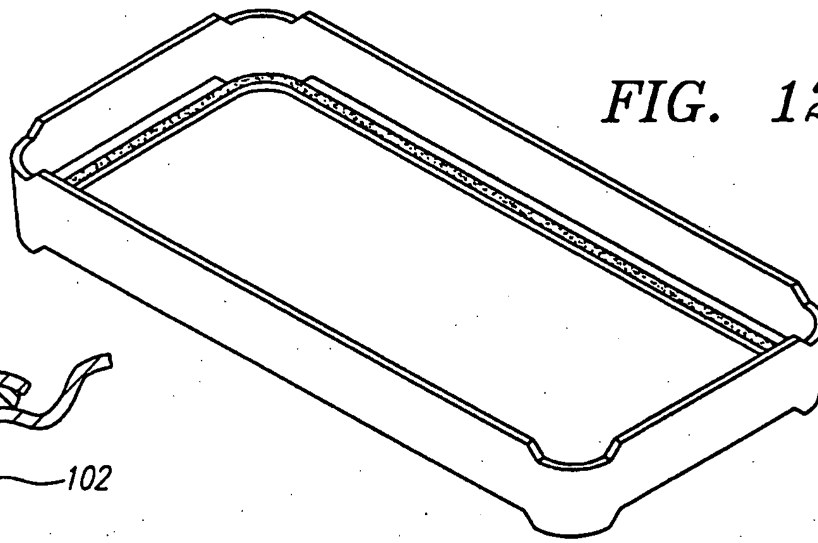


FIG. 12B

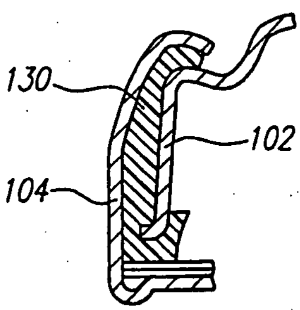


FIG. 12D-1

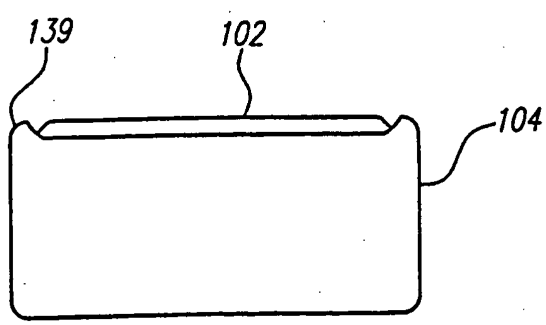


FIG. 12C

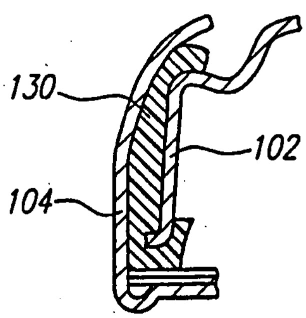


FIG. 12D-2

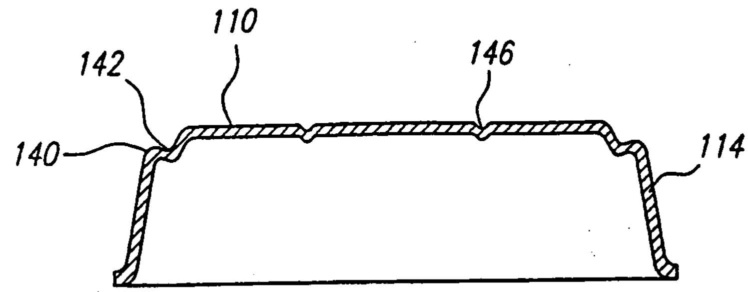


FIG.13

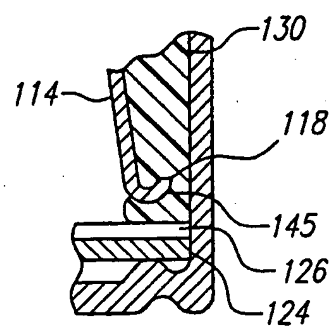


FIG. 14

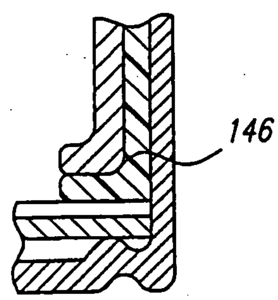


FIG. 15

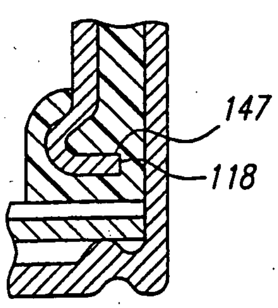


FIG. 16

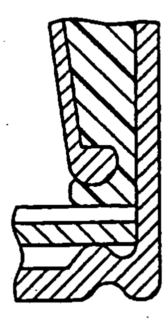


FIG. 17

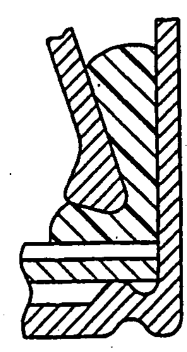


FIG. 18

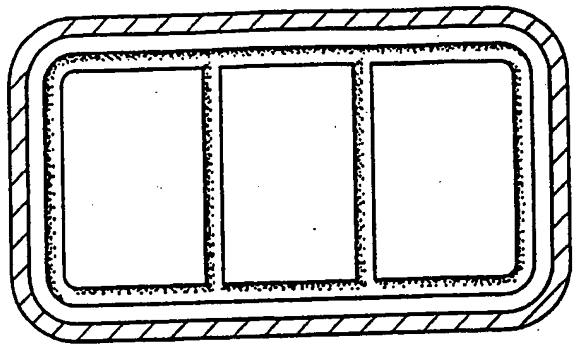


FIG. 19

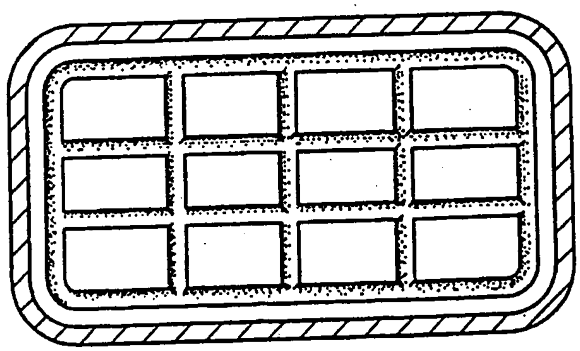


FIG. 20

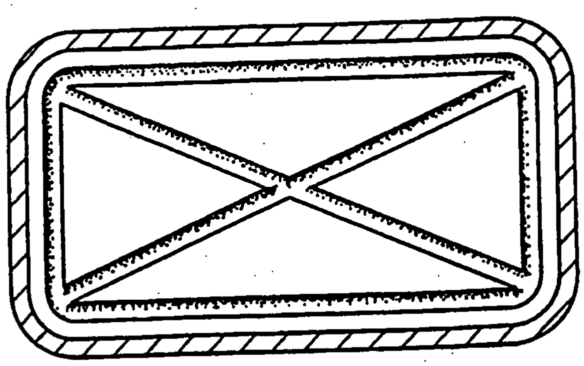


FIG. 21

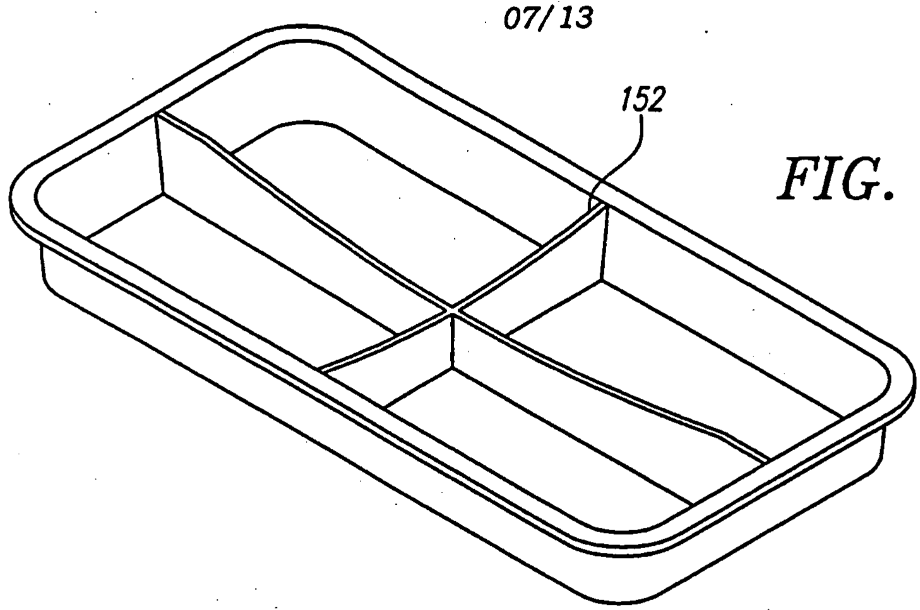


FIG. 22

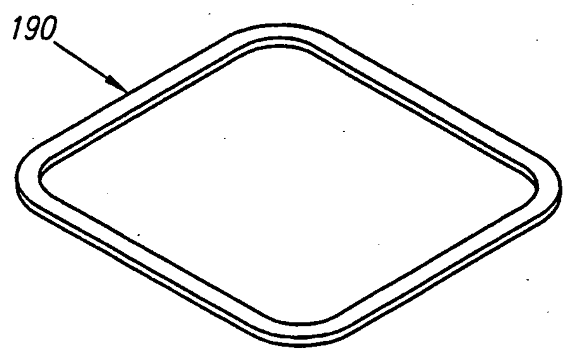
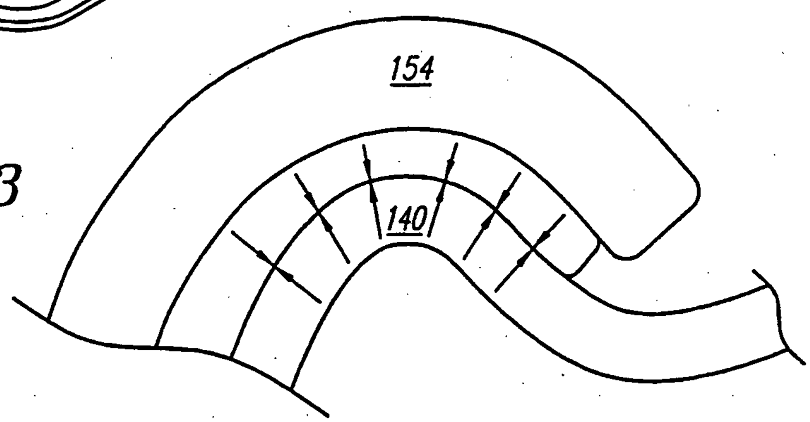


FIG. 22A

FIG. 23



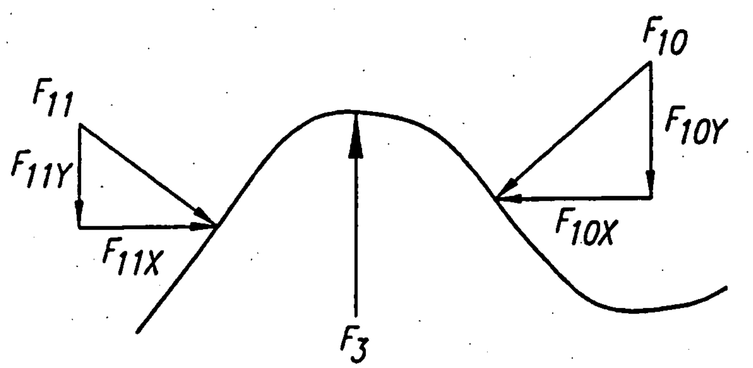


FIG. 24

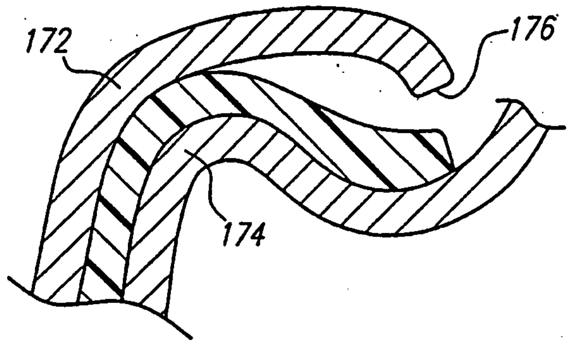


FIG. 25A

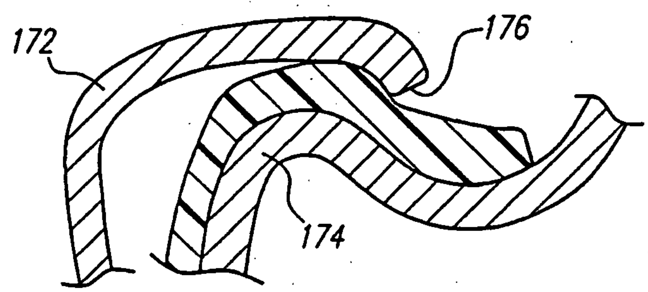


FIG. 25B

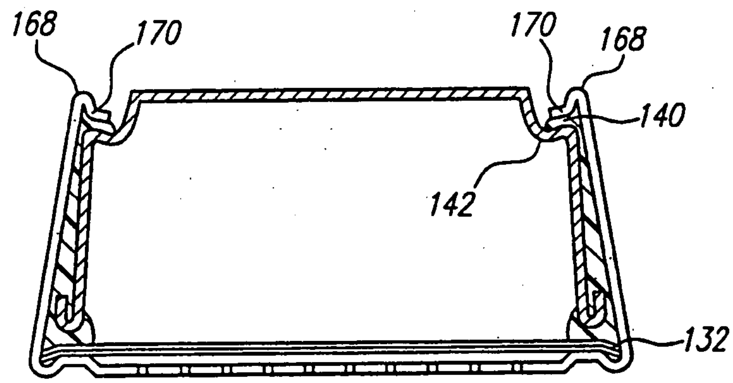


FIG. 26

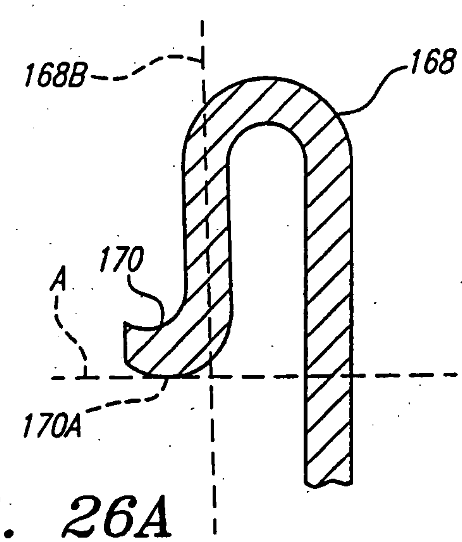


FIG. 26A

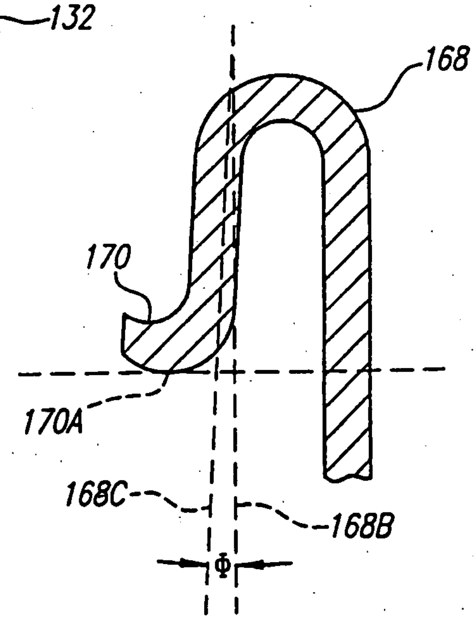


FIG. 26B

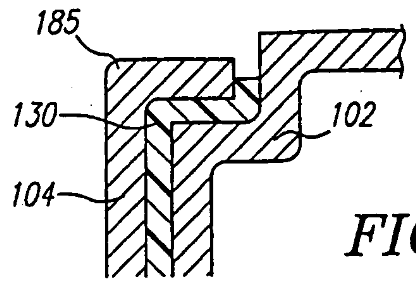


FIG. 27

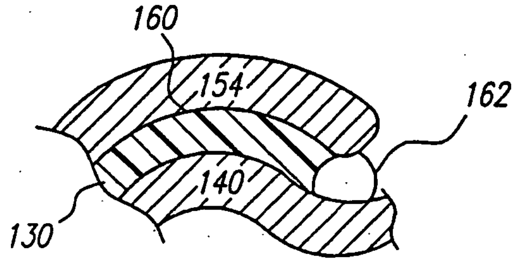


FIG. 28

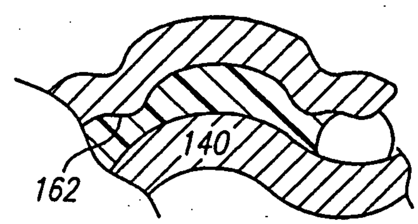


FIG. 29

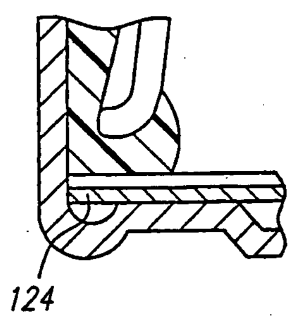


FIG. 30A

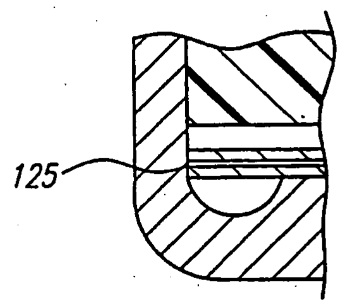


FIG. 30B

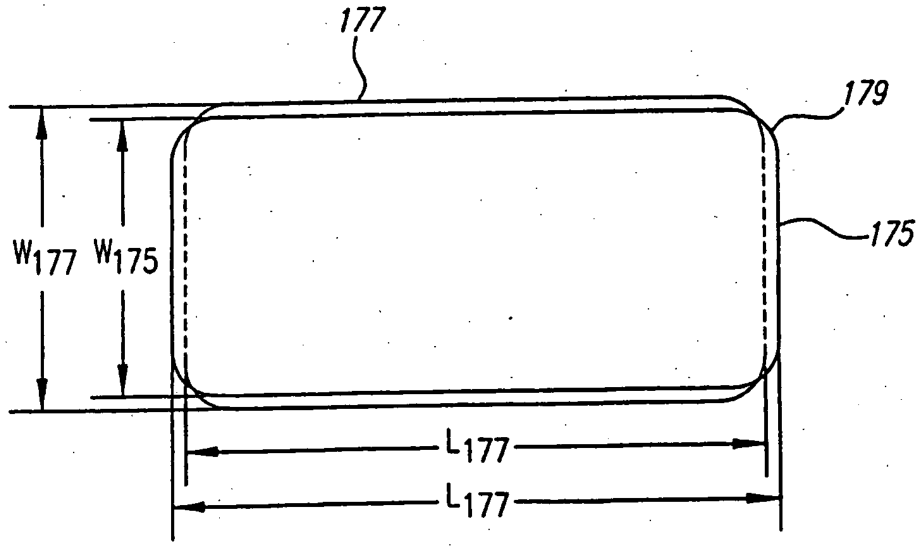


FIG. 30C

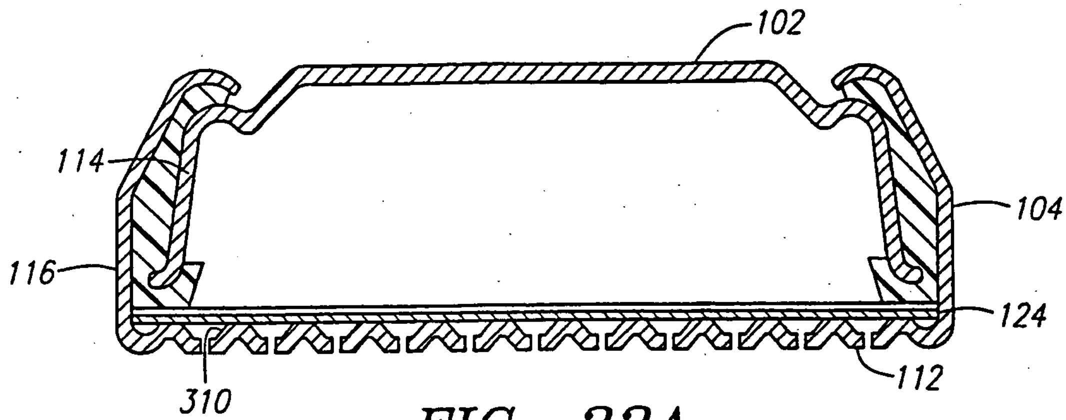


FIG. 33A

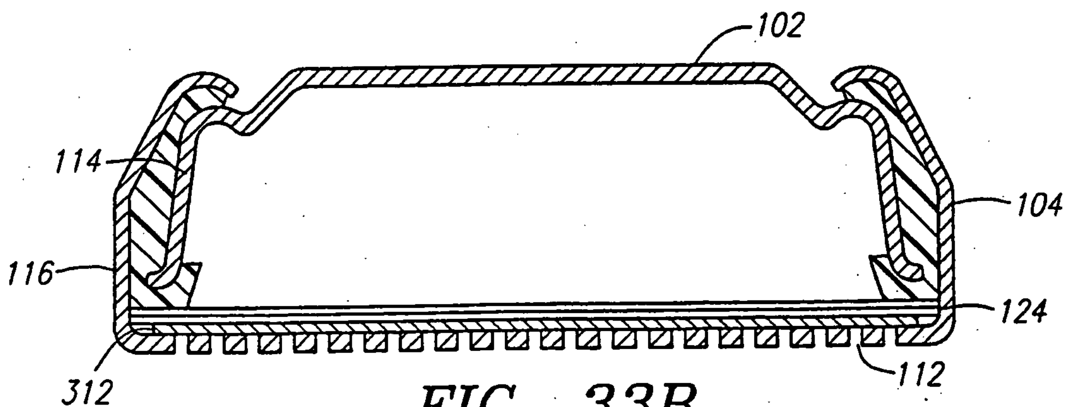


FIG. 33B

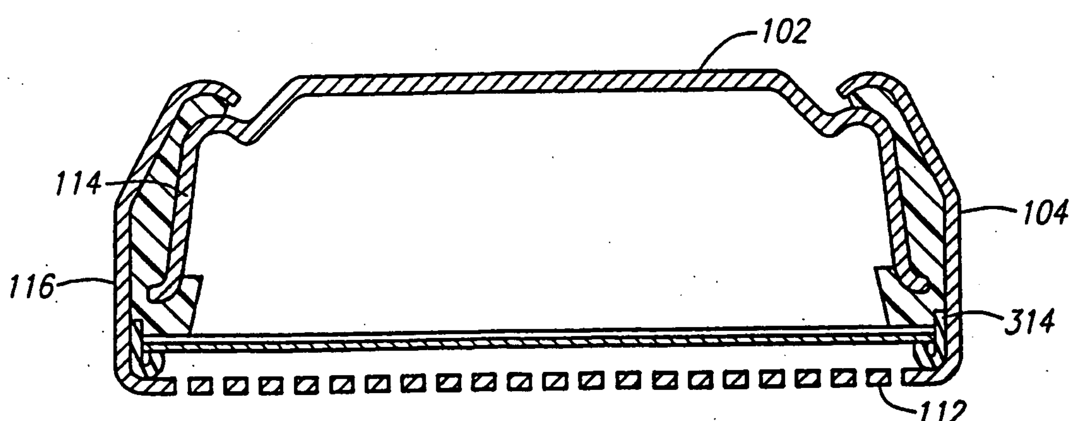


FIG. 33C

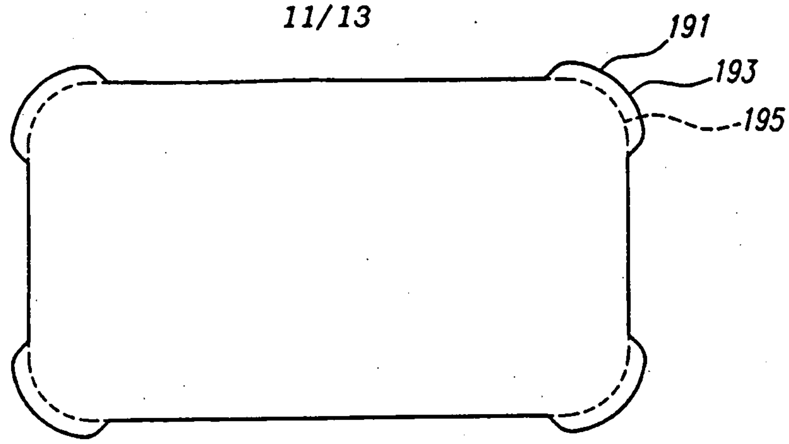


FIG. 31

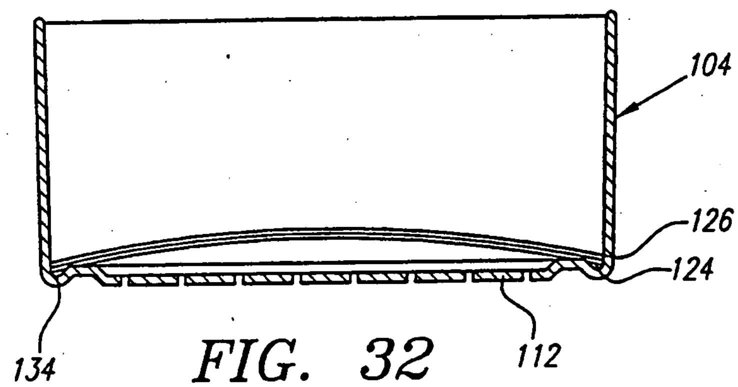


FIG. 32

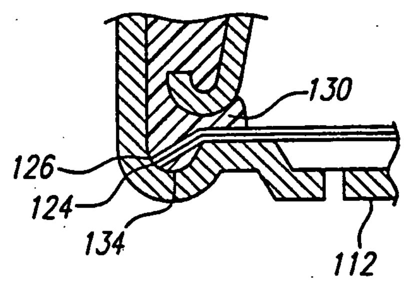


FIG. 33

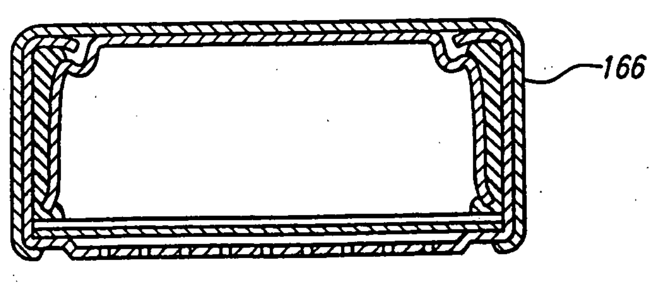


FIG. 34

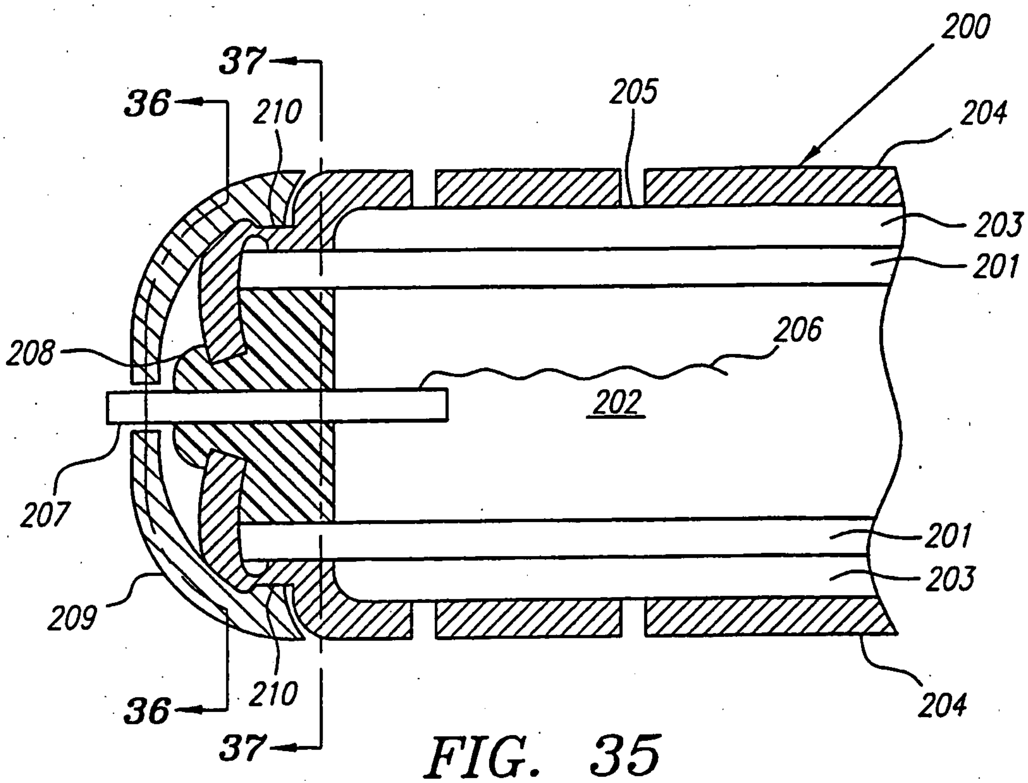

37
36
210
205
200
204
203
201
208
206
202
207
201
203
209
210
36
37
204

FIG. 35

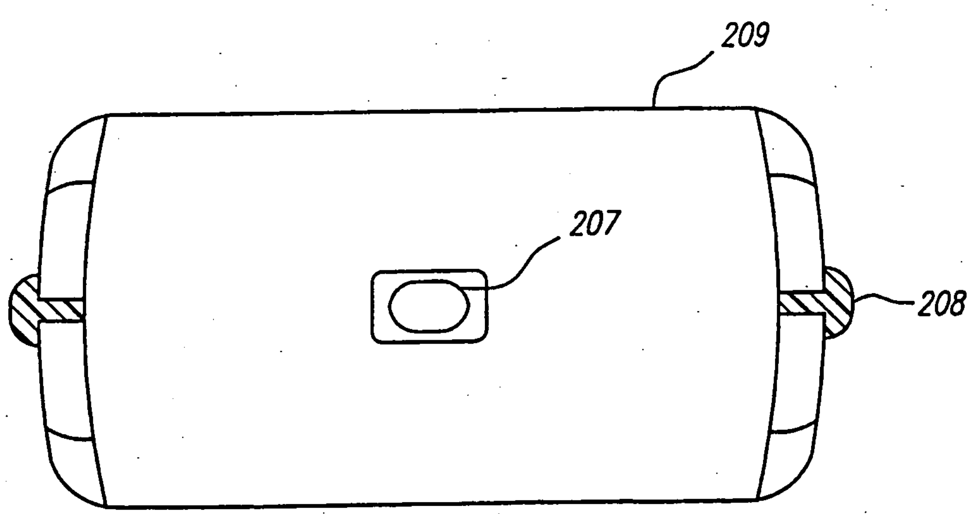

209
207
208

FIG. 36

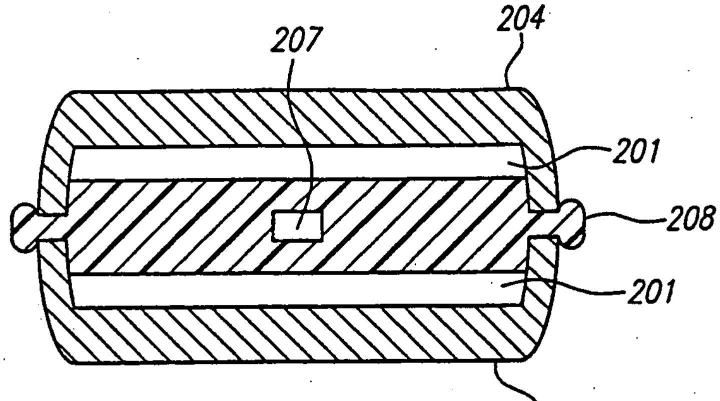


FIG. 37

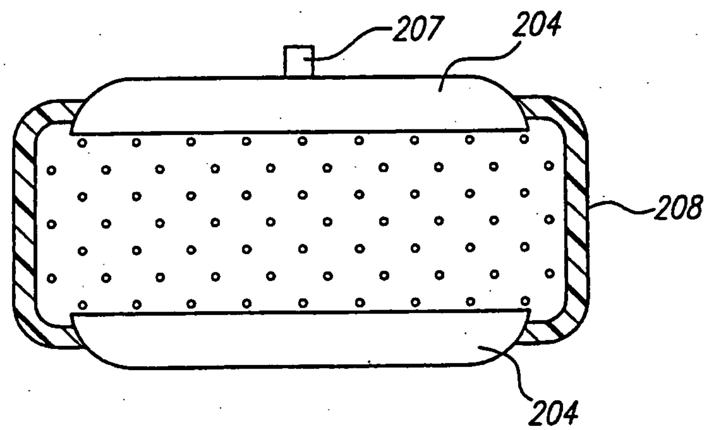


FIG. 38

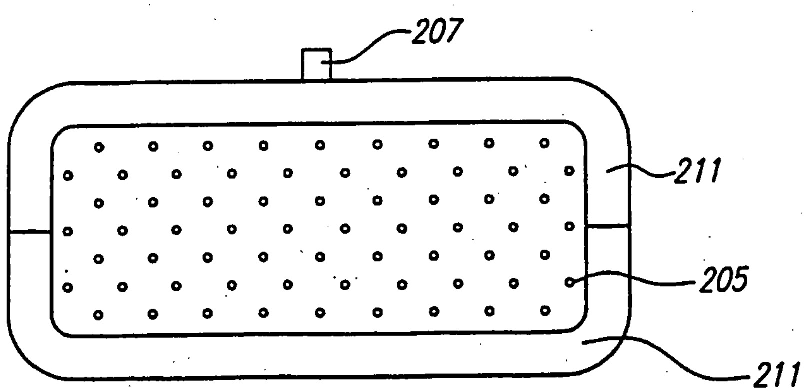


FIG. 39

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 99/28253

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 H01M12/06 H01M2/02

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 H01M

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5 556 722 A (NARUKAWA SATOSHI ET AL, SUMOTO, JP) 17 September 1996 (1996-09-17) cited in the application column 2, line 19 -column 3, line 21 figures 1,2	1-26
A	US 5 662 717 A (BURNS JOHN DAVID, DURHAM, US) 2 September 1997 (1997-09-02) cited in the application column 7, line 21 -column 10, line 24 figures 2,3	1-26
A	US 5 537 733 A (KOZAWA HIDEAKI ET AL, YOKOHAMA, JP) 23 July 1996 (1996-07-23) cited in the application figures 2,11A-11I	1-26

-/--

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance
"E" earlier document but published on or after the international filing date
"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
"O" document referring to an oral disclosure, use, exhibition or other means
"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
17 May 2000	25/05/2000

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2, NL – 2280 HV Rijswijk, Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Peis, S

1

International Application No
PCT/US 99/28253

C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication,where appropriate, of the relevant passages	Relevant to claim No.
A	GB 2 109 622 A (DURACELL INT, BETHEL, US) 2 June 1983 (1983-06-02) page 2, line 101 -page 3, line 103 figure 1	1-26
A	EP 0 123 201 A (VARTA BATTERIE, HANNOVER, DE) 31 October 1984 (1984-10-31) page 3, line 29 -page 4, line 35 figures 1,2	1-26

1

INTERNATIONAL SEARCH REPORT

Information on patent family members

Inter   nal Application No
PCT/US 99/28253

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 5556722 A	17-09-1996	JP 3015667 B	06-03-2000
		JP 7326331 A	12-12-1995
US 5662717 A	02-09-1997	EP 0751578 A	02-01-1997
		US 5721065 A	24-02-1998
		US 5658356 A	19-08-1997
		US 5945234 A	31-08-1999
US 5537733 A	23-07-1996	JP 6044951 A	18-02-1994
		JP 6231799 A	19-08-1994
		JP 6260153 A	16-09-1994
		JP 6267514 A	22-09-1994
		US 5372897 A	13-12-1994
		US 5490867 A	13-02-1996
GB 2109622 A	02-06-1983	CA 1185318 A	09-04-1985
EP 0123201 A	31-10-1984	DE 3314624 A	25-10-1984
		AU 558104 B	15-01-1987
		AU 2705084 A	25-10-1984
		BR 8401292 A	26-02-1985
		CA 1216886 A	20-01-1987
		DE 3477314 D	20-04-1989
		DK 65384 A	23-10-1984
		IL 71586 A	31-08-1987
		JP 1838725 C	25-04-1994
		JP 5050827 B	30-07-1993
		JP 59205169 A	20-11-1984
		US 4557983 A	10-12-1985